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THE BRITISH JOURNAL OF RADIOLOGY

Volume 63 Number 752 August 1990

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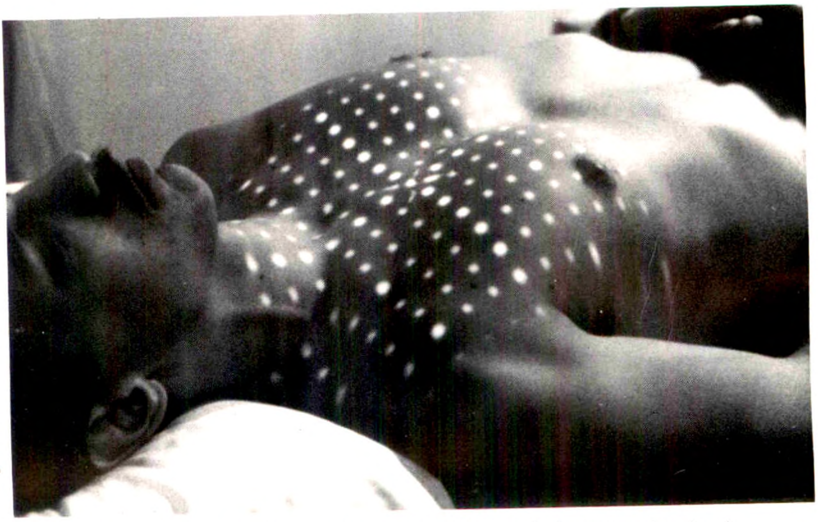

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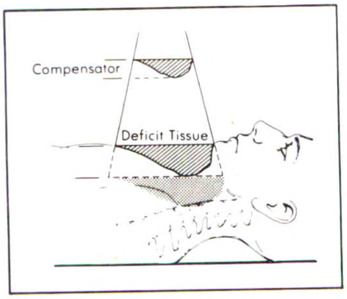

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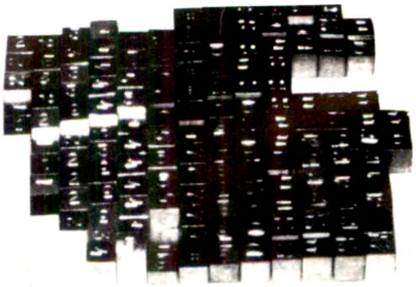

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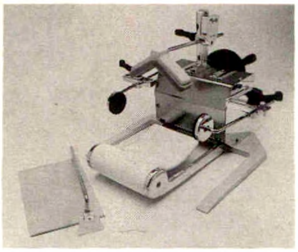

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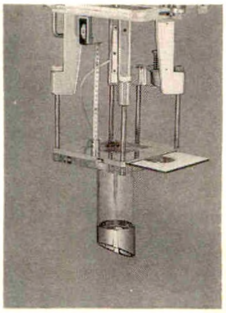

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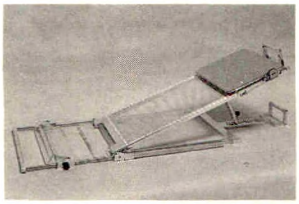

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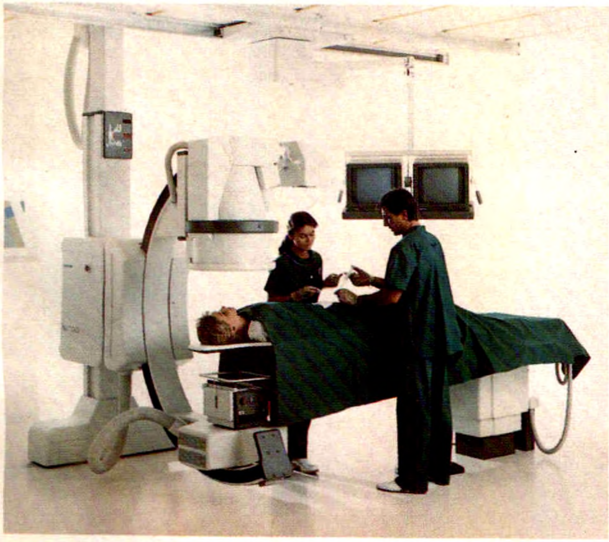

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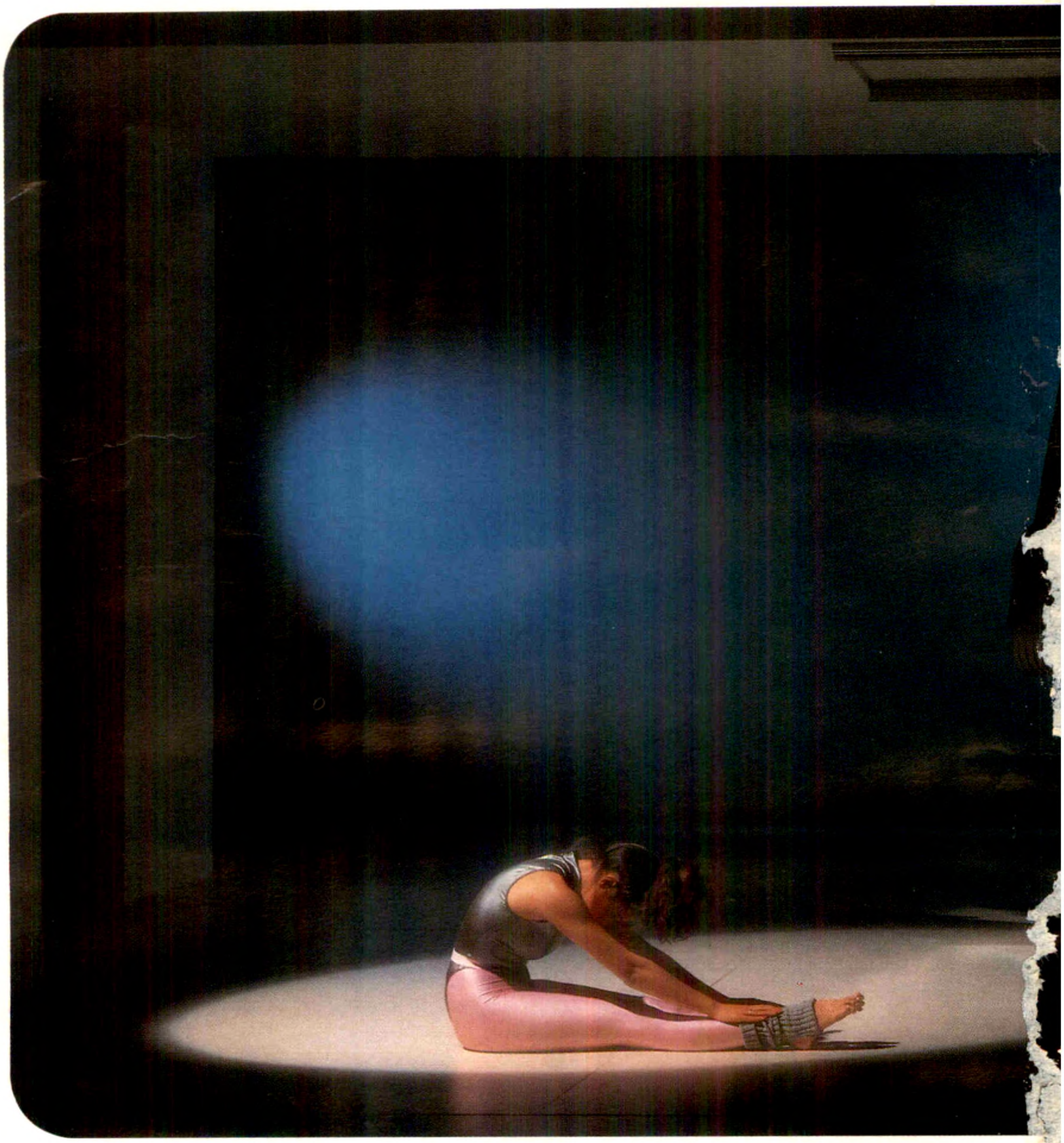

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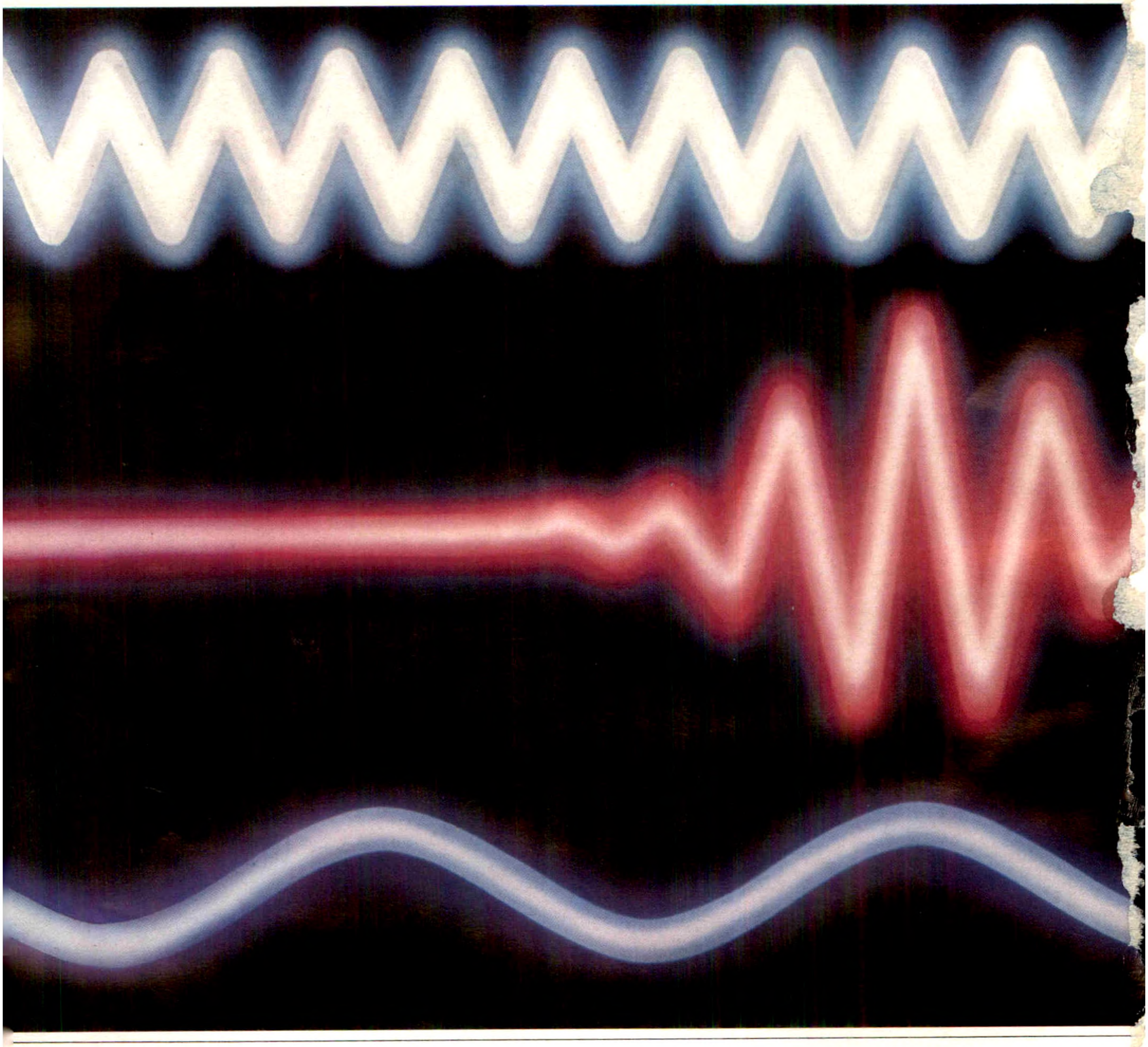

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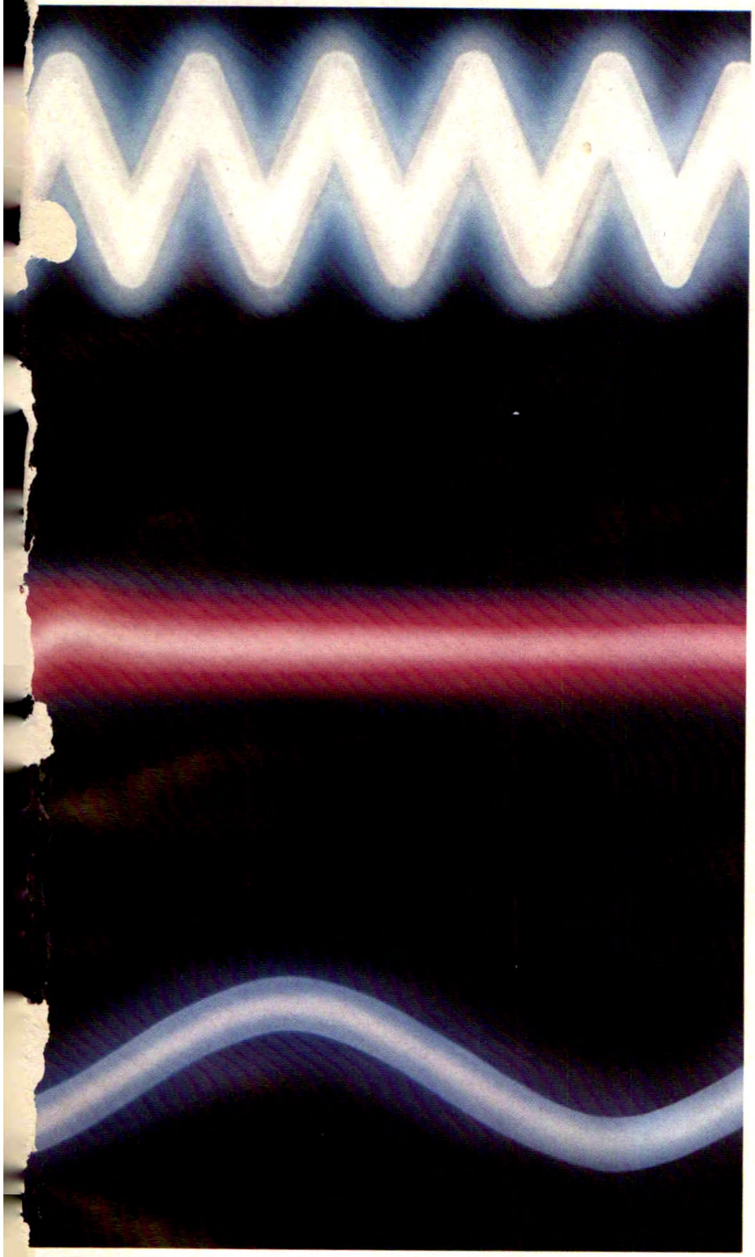

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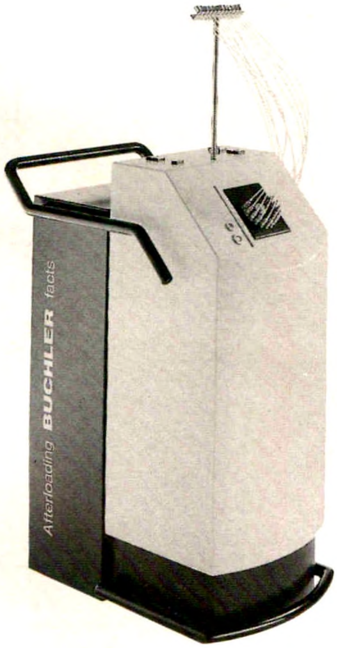

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The British Journal of Radiology

Magnetic resonance of diseased skeletal muscle: combined T_1 measurement and chemical shift imaging

By Antti E. Lamminen, MD, *Jukka I. Tanttu, MSc, *Raimo E. Sepponen, PhD, Ilkka J. I. Suramo, MD and †Helena Pihko, MD

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(*Received November 1989 and in revised form February 1990*)

Abstract. Magnetic resonance examinations of skeletal muscle with differential T_1 relaxation time measurements were performed in 19 patients with muscular dystrophies and congenital myopathies, and in eight control subjects. A field echo chemical shift imaging technique was used. T_1 values of muscular tissue were measured from the primary composite images, and differential T_1 values were calculated separately from water and fat images. Longitudinal relaxation times of skeletal muscle were significantly increased in both dystrophies and myopathies. The results of differential relaxation time measurements suggest that intramuscular fat reduces the abnormal increase in T_1 of diseased muscle tissue. When characterizing diseases of skeletal muscle by T_1 relaxation time measurements, the contribution of secondary fatty infiltration must be considered.

Proton magnetic resonance has been used to evaluate diseased skeletal muscle in both *in vivo* (Fisher et al, 1986; Murphy et al, 1986; Schreiber et al, 1987; Lamminen et al, 1989) and *in vitro* studies (Misra et al, 1982; Borghi et al, 1983; Polak et al, 1988). Muscular atrophy has been macroscopically assessed, and the distribution of fatty degeneration in muscles has been evaluated. However, more detailed characterization of primary muscle disease processes is needed. Tissue characterization is mainly based on differences in the proton relaxation times.

A significant prolongation of the proton longitudinal relaxation time (T_1) of dystrophic muscle tissue has been observed in experimental studies (Misra et al, 1982, 1984). However, the T_1 relaxation behaviour, and thus the tissue characterization of dystrophic and myopathic muscles in *in vivo* studies, may be disturbed by secondary fatty infiltration. An increase in the intramuscular fat content affects T_1 of muscles (Fisher et al, 1986); also, T_1 relaxation is biexponential in tissues with a significant fat component (Fullerton et al, 1985). Although a preliminary report of differential relaxation time measurements with chemical shift imaging in a single patient with myositis has recently been published (Poon et al, 1989), there have been no studies of larger patient populations.

In the present study, we evaluated *in vivo* the T_1 changes of skeletal muscle in patients with muscular dystrophies and congenital myopathies with a low field imaging system. Low field has been advocated for musculoskeletal studies when good T_1 differentiation is needed (Misra et al, 1984; Smith, 1988). In order to assess the effect of fatty infiltration by differential relaxation time measurement, a field echo chemical shift imaging technique feasible for low fields was used.

Methods and patients

A total of 19 patients were examined: 10 patients with progressive muscular dystrophies (ages 4.2–17.3 years, mean 9.8 years; seven male, three female), and nine patients with congenital myopathies (ages 3.0–28.0 years, mean 15.7 years; four male, five female). Eight normal subjects (ages 4.5–18.5 years, mean 12.8 years; four male, four female) were studied as controls. In all patients, the diagnosis had been verified by muscle biopsy. The dystrophy group consisted of six Duchenne dystrophies, one Becker-type dystrophy and three unclassified dystrophies. In the congenital myopathy group, there were four nemaline myopathies, two multicore myopathies and three unclassified myopathies. The average duration of symptoms was 6.1 years in patients with dystrophy, whereas the mean symptomatic period in patients with other myopathies was 9.1 years.

A resistive whole-body magnetic resonance imaging (MRI) system operating at 0.02 T, corresponding to a proton resonance frequency of 0.833 MHz (Instrumentarium Corp., Helsinki, Finland), was used. Transaxial

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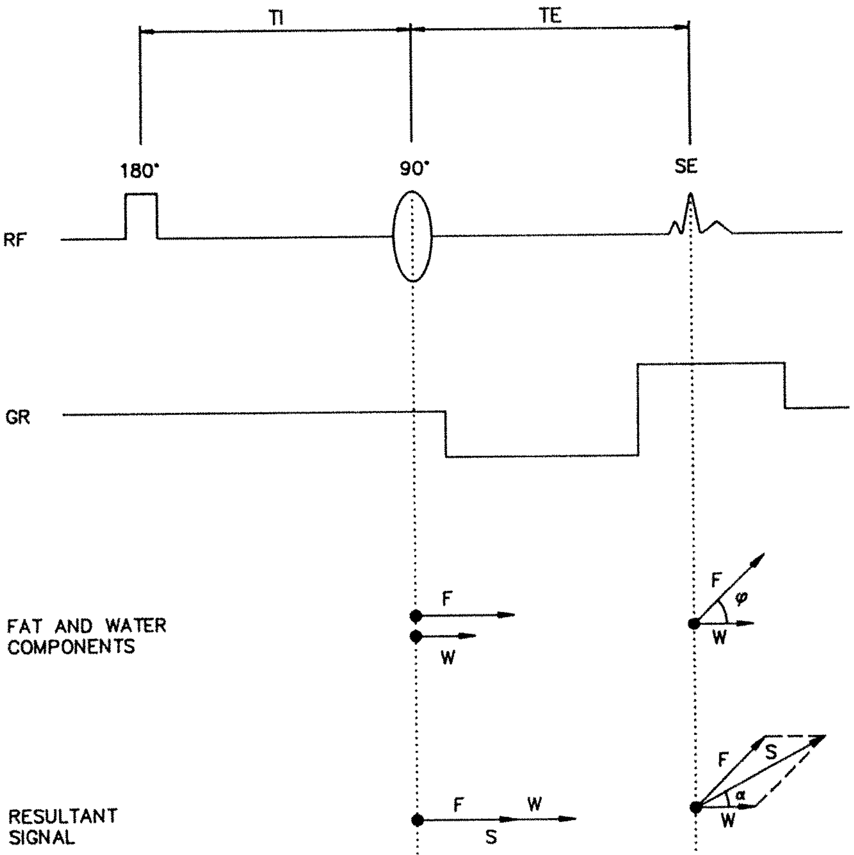


Figure 1. The method used for fat/water discrimination. The fat (F) and water (W) components are in the same phase immediately after the 90° pulse. Gradient echo is used. The phase difference (ϕ) between these components is accumulated during the time to echo TE. The resultant signal has a magnitude S and a phase α. The phase information is used to produce separated fat and water images. In the inversion recovery sequence, composite pulses are applied at the inversion time before the 90° pulse. RF, radiofrequency pulses; SE, signal; GR, readout gradient.

slices of both thighs and legs were first obtained; from these images, a region of limb with signs of abnormal intramuscular signal was selected. An extremity coil was then employed to increase the signal-to-noise ratio and transaxial, 10 mm thick slices were obtained for the actual study. Imaging time was 8.5 min/image. Matrix size was 128 × 256.

Separated water and fat images were produced. At 0.02 T, the frequency difference between fat and water due to chemical shift (Δf) is about 3 Hz. Conventional chemical shift imaging methods are therefore not applicable. A method developed for low field imaging (Tanttu et al, 1987) was used. This method requires reconstruction of both a magnitude image and a phase image. The principle of the method is illustrated in Fig. 1. The phase difference (ϕ) between water and fat at echo delay time TE in a gradient echo sequence is

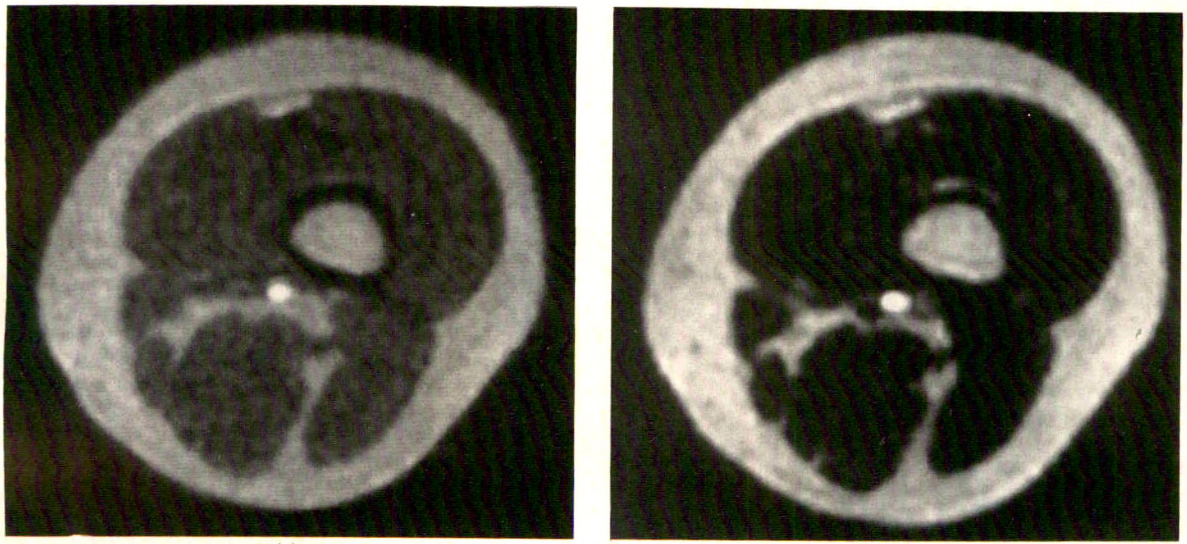
$$\phi = 2\pi \cdot \Delta f \cdot TE.$$

The resultant signal detected has a magnitude S and a phase α (Fig. 1). This results in a phase difference of 40° when TE is 40 ms. Based on the reconstructed magnitude and phase images, the water and fat components (S_w and S_f, respectively) can be extracted in order to produce separated water and fat images

$$S_w = S\cos\alpha - S\sin\alpha\cot(\phi)$$
$$S_f = S\sin\alpha/\sin(\phi).$$

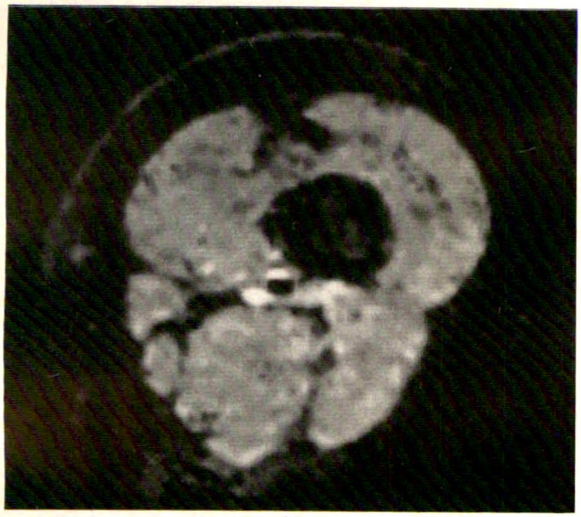
In this study, we used two-dimensional polynomials fitted on water phantom images to correct the phase errors due to main field inhomogeneities.

For anatomical details, a partial saturation image with a repetition time (TR) of 250 ms and an echo delay time (TE) of 40 ms was obtained. T_1 calculations were based on two inversion recovery measurements with a TR of 500 ms, TE of 40 ms and inversion times (TI) of 25 ms and 175 ms. All images were produced using gradient echoes. This inversion was performed with composite pulses, which effectively reduced the radiofrequency field inhomogeneity errors (Freeman et al, 1980). Because of the high absolute homogeneity (< 10 Hz within the imaging volume) of our system, the



(a)

(c)



(b)

Figure 2. Transaxial magnetic resonance images of thigh in a normal subject: (a) primary composite image (PS 250/40 ms), and corresponding water (b) and fat (c) images, produced with the gradient echo fat/water discrimination technique.

offset effects on the inversion are negligible. The reproducibility of the T_1 measurement was tested using manganese chloride ($MnCl_2$) solutions of various concentrations. Reproducibility of the calculated T_1 values in the range 100–500 ms was better than 4%.

T_1 values were calculated from two regions of interest (ROI), with a sampling area of about 20 pixels each, placed within the cross-sectional areas of muscles; one ROI was placed anteriorly and the other posteriorly. T_1 values of muscle tissue were measured from the primary composite image, the water image and also the fat image, when possible. Student's *t*-test was used to assess statistical significance.

Results

The primary composite image which contains both water and fat components, and the separate water and fat images of a normal subject are shown in Fig. 2. Corresponding images of a patient with Duchenne muscular dystrophy are shown in Fig. 3. The images are slightly T_2-weighted for normal muscle tissue, owing to the TE of 40 ms, which is comparable to T_2 values of normal muscle (Bottomley et al, 1984).

The calculated mean T_1 values of skeletal muscle from the primary composite images and the separate water and fat images (T_{1c}, T_{1w} and T_{1f}, respectively) are shown in Table I. T_{1f} values of muscular tissue could not be measured from the normal subjects, because of sparsity of fat in normal muscle fascicles.

The mean T_{1c} values of skeletal muscle in both dystrophic and myopathic patients are significantly higher ($p < 0.01$) than those of normal muscles. The increase in T_{1w} values between normal and diseased muscles is even greater, and also statistically significant ($p < 0.01$). The

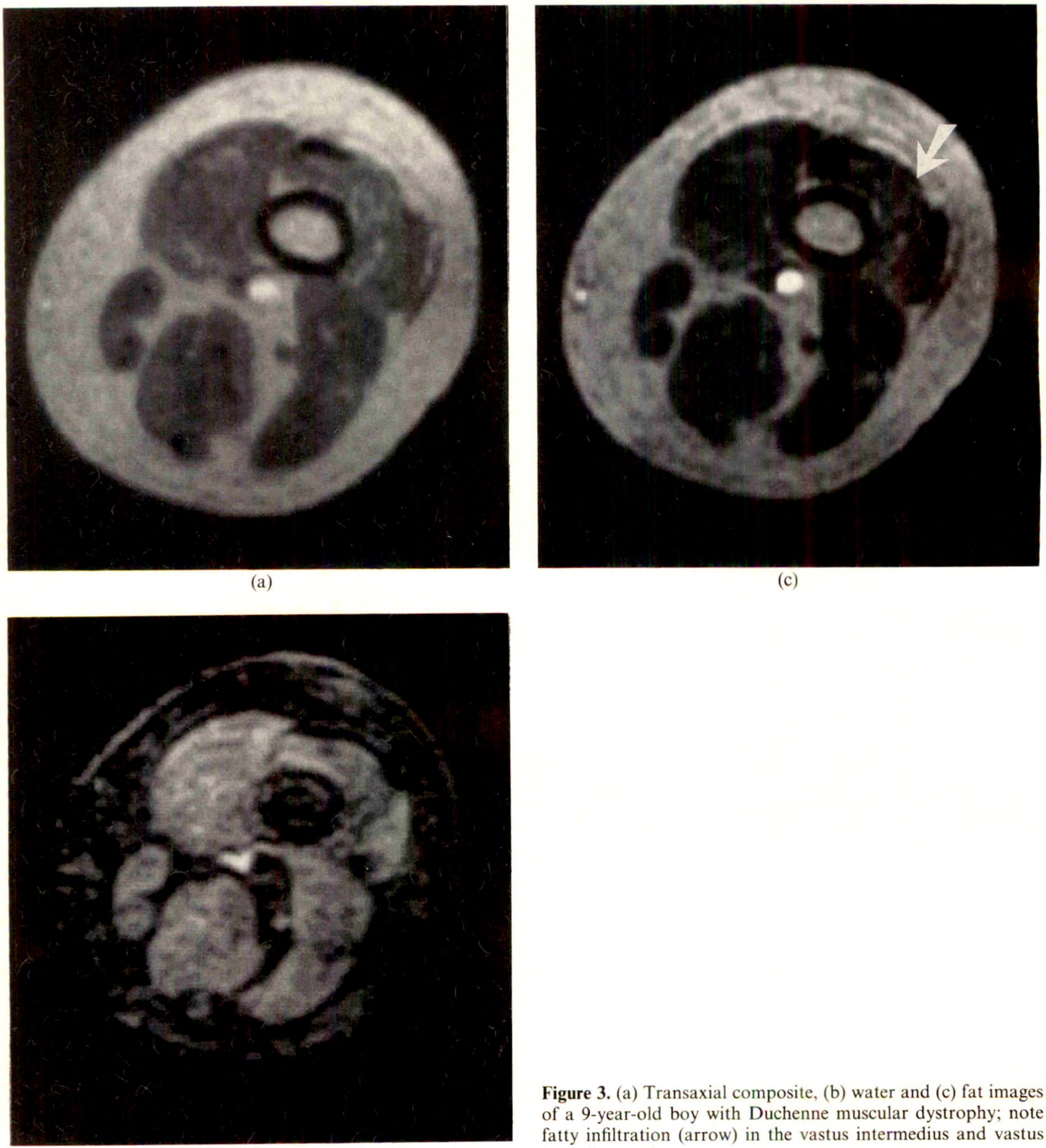

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Figure 3. (a) Transaxial composite, (b) water and (c) fat images of a 9-year-old boy with Duchenne muscular dystrophy; note fatty infiltration (arrow) in the vastus intermedius and vastus lateralis muscles.

muscle T_{1c} and T_{1w} values of dystrophy patients deviate more from normals than those of congenital myopathy patients, although this difference is not statistically significant.

The relationship between T_{1c} and T_{1w} values is illustrated in Fig. 4. There is a difference between T_{1c} and T_{1w} measurements, the range of which increases with increasingly pathological longitudinal relaxation times of actual muscles tissue (T_{1w}).

Discussion

Most pathological processes alter the proton relaxation times of tissues. T_1 and T_2 values are more reliable for detecting diffuse muscle disease processes than evaluation of the size and contour of muscles (Fisher et al, 1986). A significant increase in the T_1 values of dystrophic muscle tissue has been observed in experimental studies, and a direct relationship between T_1 and the severity of muscle disease was suggested (Misra et al,

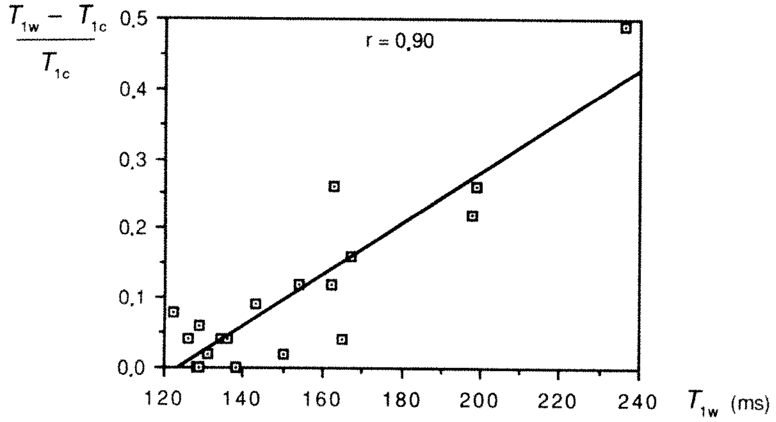

Figure 4. The relative difference between longitudinal relaxation times measured from the composite image (T_{1c}) and from the water image (T_{1w}), shown as a function of T_{1w}, in 19 patients with primary skeletal muscle disease.

Table I. Mean longitudinal relaxation times (ms) of skeletal muscle measured from primary composite images (T_{1c}), water images (T_{1w}) and fat images (T_{1f})

	T_{1c}		T_{1w}		T_{1f}	
	Mean	SEM	Mean	SEM	Mean	SEM
Normals	126.0	3.0	124.0	3.3	—	—
Myopathies	141.1	3.4	149.0	8.8	121.6	4.1
Dystrophies	145.9	3.4	167.2	7.6	123.1	3.8

SEM = standard error of the mean.

1982). In humans, accumulation of collagenous and fatty tissue in dystrophic muscles is a prominent feature and usually regarded as a secondary phenomenon (Cullen & Mastaglia, 1980). An increase in the intramuscular fat content changes the longitudinal relaxation of muscle tissue in two ways: the T_1 values measured from the composite proton signal are shortened (Fisher et al, 1986), and the relaxation process becomes biexponential in tissues with a significant fat component (Fullerton et al, 1985). In a recent study on Duchenne muscular dystrophy (Matsumura et al, 1988), an increase in T_1 of muscles at the pre-clinical stage of the disease was observed. During progression of the disease, the T_1 values of the muscles decreased. The study was performed using composite images, containing the contributions from both water and fat, for the T_1 measurements. Thus, it is probable that the T_1 of dystrophic and myopathic muscle tissue is altered in *in vivo* studies by secondary fatty infiltration of the diseased muscles.

The relaxation behaviour of a tissue cannot generally be described by a single exponential. Transverse relaxation often has two or more components; in longitudinal relaxation, this phenomenon is also present (Bottomley et al, 1984). If there are two or more different types of tissues within a voxel it is likely that a single exponential fit is unsatisfactory (Komu et al, 1989). In diseased skeletal muscles, there will often be a significant fat component. Therefore, in this study, the T_1 values were calculated from separate water images, as well as from composite images, using the method described above.

We were able to demonstrate clearly in practice the net reduction in T_1 of diseased skeletal muscle produced by the intramuscular fat component. The mean muscle T_1 values of both dystrophic and myopathic patients were higher than those of the normal muscles; this is in accordance to the earlier *in vitro* results (Misra et al, 1982), and is probably a result of altered interaction between cellular water and macromolecules in diseased muscles. The results based on the differential T_1 measurements of fat and water components suggest that in composite images, secondary fatty infiltration of muscles plays a role in partially reducing the increase in T_1 associated with muscular dystrophy and congenital myopathies.

When measuring relaxation times from two points of the relaxation curve, there exists a danger of systematic errors. However, the use of more than two measuring points easily leads to impracticably long examination times, and in clinical studies, the routine two-point method has been found to yield reproducible relaxation time measurements (Kjos et al, 1985). In the present study, elimination of systematic errors was especially emphasized by using the inversion recovery technique with composite pulses, combined with chemical shift imaging.

Low field magnetic resonance is especially useful for proton relaxation studies of biological tissues. In low fields, the longitudinal relaxation times T_1 are shorter and the relative differences in T_1 between different tissues are larger (Koenig et al, 1984; Bottomley et al, 1987). Because of enhanced T_1 differentiation, low frequency and low field MR has been advocated for detection of muscle disease processes (Misra et al, 1984).

Conclusion

In this study, T_1 of skeletal muscle in patients with primary muscles diseases was found to be increased. The results of differential T_1 measurements suggest that in composite images, secondary fatty infiltration of

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muscles plays a role in partially reducing the T_1 value changes associated with muscular dystrophy and congenital myopathies. Thus, when characterizing diseased skeletal muscles by T_1 relaxation time measurements, the contribution of secondary fatty infiltration must be considered.

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Linear opacities as a feature of pneumocystis pneumonia

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Abstract. Linear opacities are generally regarded as uncommon in pneumocystis pneumonia. The authors' experience suggests this is not so, and that such opacities may have diagnostic value. Chest radiographs of 22 episodes of uncomplicated pneumocystis pneumonia were reviewed and linear opacities were present in nine episodes (41%). Similar opacities were present in 11 out of 121 cases of other pneumonias (9%). Characteristically the opacities are related to the acute illness, usually one to three in number, predominantly basal, 1–4 cm long and less than 2 mm thick. Other radiographic signs of pneumocystis pneumonia were present in all cases. The pathogenesis of these linear opacities is uncertain, but it is possible that they result from areas of sub-segmental atelectasis. The frequency of such linear opacities is much greater in pneumocystis pneumonia (four times) than in other pneumonias and they therefore have some diagnostic value.

The most commonly recognized radiographic presentation of pneumocystis pneumonia is that of bilateral perihilar "ground-glass" consolidation. Less common radiographic patterns include focal consolidation, pulmonary nodules and interstitial changes. We have observed linear opacities as another unusual feature of pneumocystis pneumonia which occur with much greater frequency than in other pneumonias and therefore have some diagnostic value.

Patients and methods

The chest radiographs of all uncomplicated cases of pneumocystis pneumonia presenting to St George's Hospital between March 1987 and October 1988 were reviewed. Complicated cases that were excluded consisted of two patients with pulmonary Kaposi sarcoma and one with multiple pulmonary emboli, leaving a group of 20 patients with 22 episodes of pneumocystis pneumonia for study.

Seventeen of the 22 episodes of pneumocystis pneumonia were confirmed by transbronchial biopsy or broncho-alveolar lavage (BAL), which was performed in seven instances. In five episodes the diagnosis was based on clinical and radiological features and response to treatment with high dose cotrimoxazole or pentamidine.

The depth of inspiration on postero-anterior radiographs was estimated by relating the dome of the diaphragm in the mid-clavicular line to the anterior rib ends.

As a control, the radiographs of 121 patients with other pneumonias were studied. These consisted of cases presenting to the hospital over a 4-month period supplemented by teaching file cases.

Results

Nineteen of the 20 patients included in the study were white men; the twentieth patient was a Ugandan woman. The age of the patients ranged from 28 to 57 years with a mean of 40.3 years. All patients were known to be HIV positive at the time of diagnosis of pneumocystis pneumonia.

Linear opacities were present in nine of the 22 episodes of pneumocystis pneumonia. Fifty-six radiographs were reviewed in these nine episodes, ranging from four to 12 radiographs per episode (mean, six). Thirty-nine separate linear opacities were observed in a total of 19 of these radiographs.

Broncho-alveolar lavage was performed in seven instances altogether, including two out of nine episodes in which lines were observed. On one occasion the lines appeared on the chest radiograph 2 days later, but on the other occasion the lines were present 8 days prior to BAL. No lines were seen on the radiographs in the remaining five out of seven instances in which BAL was performed.

Typically, one to three lines were present per radiograph, and in no case were there more than six lines present either throughout the episode or on any individual radiograph. Unilateral linear opacities were more common on the right (11/19 radiographs) than on the left (2/19). Bilateral opacities were present on the other six radiographs. Most (13/19) occurred in the lower zones (Fig. 1).

Lines were usually 1–4 centimetres long (64%) but 36% were greater than 4 cm in length with a maximum length of 7 cm (Fig. 2). The majority (59%) were less than 2 mm thick, but 36% were in the 2–4 mm range with a maximum thickness of 5 mm (Fig. 3).

All the lines were transient occurring in the acute episode of pneumocystis pneumonia (Fig. 4). None antedated the parenchymal changes of pneumocystis pneumonia. In all cases, the lines resolved before, or at about the same time as, the parenchymal changes. The parenchymal changes seen in these nine episodes included the typical perihilar and lower zone consolidation in five episodes, focal consolidation in four, interstitial linear and nodular opacities in four cases (persisting after resolution of the acute infection in one

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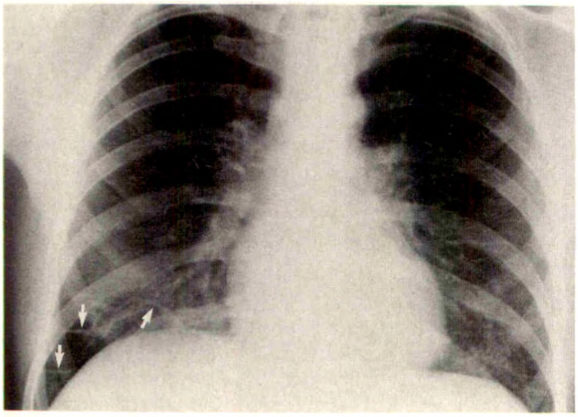


Figure 1. Bilateral lower zone "ground glass" consolidation with linear opacities (arrowed) in both lower zones in a patient with Pneumocystis carinii pneumonia.

case) and bilateral mid- and upper zone opacities resembling tuberculosis in one patient, who had been treated with inhaled pentamidine, and it has been suggested that preferential distribution of the drug to the lower zones by this method may be a factor in the upper zone predominance of the infection (Fig. 2).

A distinction is made between the linear opacities described above and septal lines as defined by the

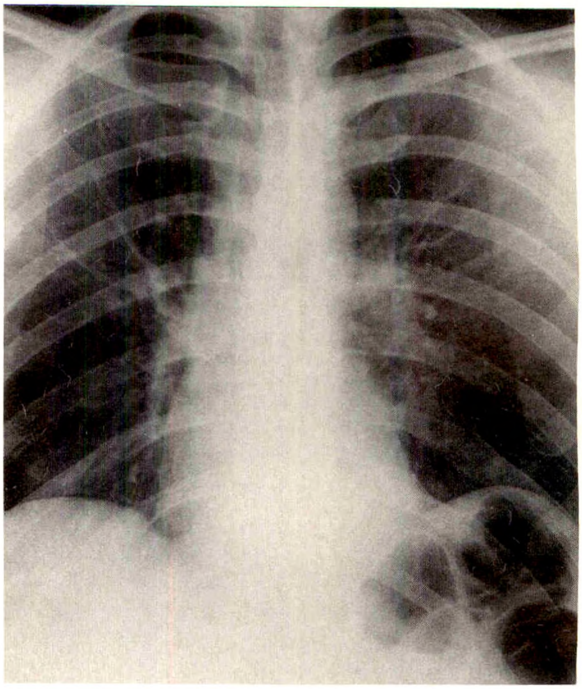
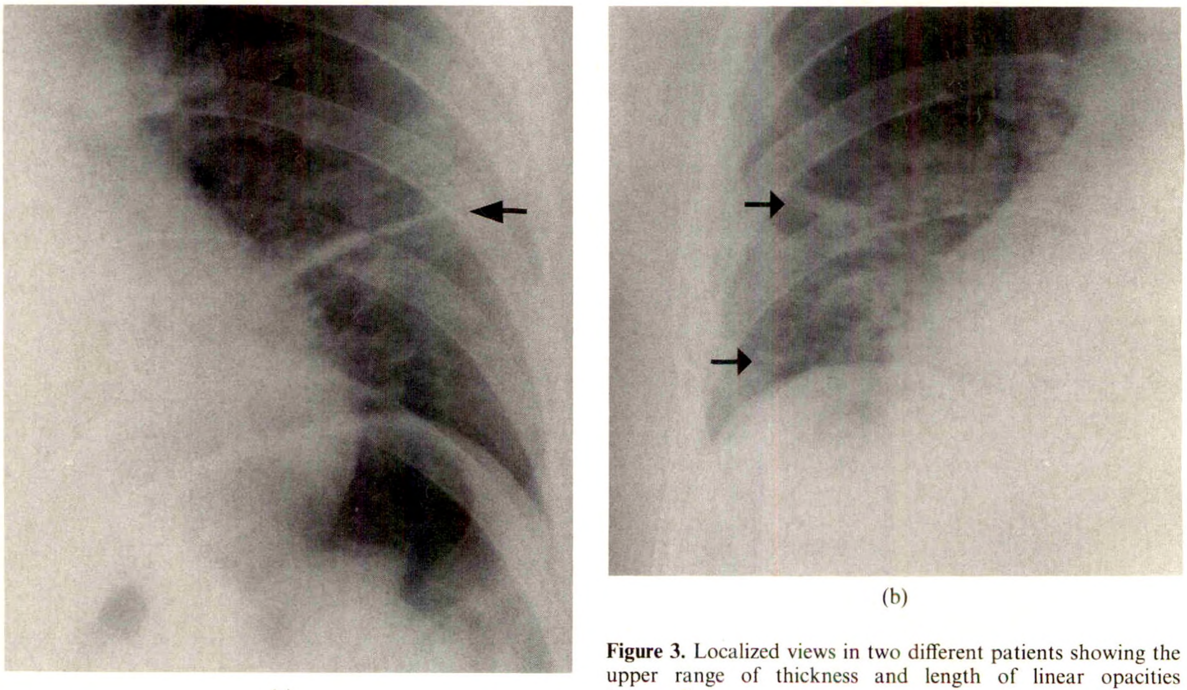


Figure 2. Linear opacities in both upper zones in a patient with recurrent infection. The opacities are longer than usual and distributed atypically, being confined to the upper zones. The patient had been treated with inhaled pentamidine.



(a)

(b)

Figure 3. Localized views in two different patients showing the upper range of thickness and length of linear opacities (arrowed).

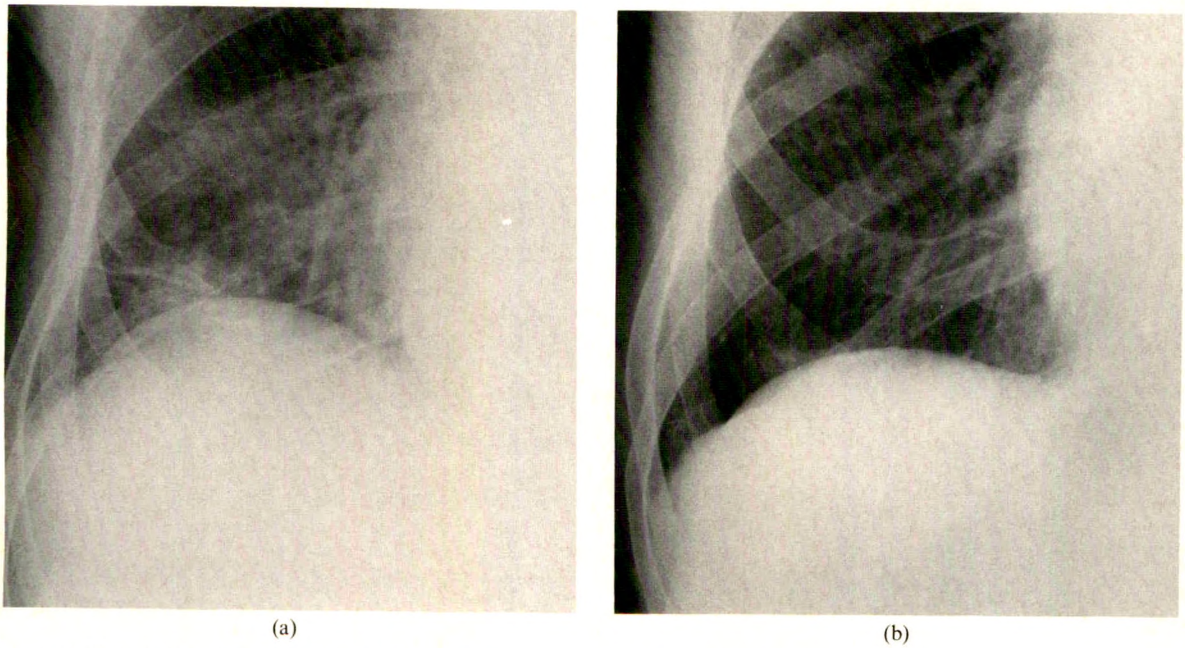

(a) (b)

Figure 4. Detail of radiographs taken 4 weeks apart in a patient (a) during the acute illness and (b) after recovery, showing resolution of the linear opacities in the lower zone.

Fleischner Society Committee on Nomenclature (Fleischner Society, 1984). The latter were seen in four episodes of pneumocystis pneumonia in our series. A small pleural effusion was seen in only one case.

An estimation of the depth of inspiration achieved in those patients with linear opacities and those without was compared by counting the anterior ribs visible above the diaphragm. The height of the right hemidiaphragm expressed as anterior rib height was 5.32 ± 0.6 standard deviation (SD) in those with linear opacities and 5.82 ± 0.54 SD in those without. The shallower depth of inspiration in patients with linear opacities was statistically significant (χ^2, $p < 0.0005$).

Cytomegalovirus (CMV) was isolated in six of the 22 episodes of pneumocystis pneumonia in the study group at or around the time of the acute illness. Linear opacities were present in one of these cases only. No other organisms were isolated from either sputum or blood culture or from trans-bronchial biopsy or washings during this time.

The radiographs of eleven control patients showed linear opacities. The aetiology of the pneumonia in these patients was gram negative bacterial (5/11), pneumococcal (2/11), mycoplasma (2/11) and unknown (2/11).

Discussion

The usual radiographic features of *Pneumocystis carinii* pneumonia have been reported extensively in the literature (Falkenbach et al, 1961; Forrest, 1972; DeLorenzo et al, 1987). Atypical features are also well recognized, and in one large series occurred in approximately 10% of cases (DeLorenzo et al, 1987). Unusual features include focal or lobar consolidation (Forrest, 1972), isolated pulmonary nodules simulating a mass lesion (Barrio et al, 1986; Bier et al, 1986), upper lobe opacities simulating tuberculosis (Milligan et al, 1985), spontaneous pneumothorax and thin-walled cysts (DeLorenzo et al, 1987). Persistent interstitial changes have also been described (Vanley et al, 1982).

Linear opacities are included in atypical features listed in several papers (Gamsu et al, 1982; Gedroyc & Reidy, 1985) but they have not been described in detail and their frequency has not been established. Doppman et al (1975) reported a 56% prevalence of atypical features in a review of 30 cases of pneumocystis pneumonia including two patients with linear atelectasis. In our study, linear opacities were seen in 41% of a series of 22 episodes of uncomplicated pneumocystis pneumonia. This is perhaps surprising as it has not been a prominent feature in earlier series. We have reviewed our study group and cannot identify any particular features which might distinguish this population from other reported series and the cause of this variation is not apparent.

Typically, no more than three such opacities were present at any one time. They occurred predominantly in the lower zones and were more common in the right lung. Most measured 1–4 cm in length (64%), although 36% were longer. Fifty-nine per cent of lines were less than 2 mm in thickness. All lines were transient and only seen during the acute infective episode.

It seems likely that these opacities are due to small

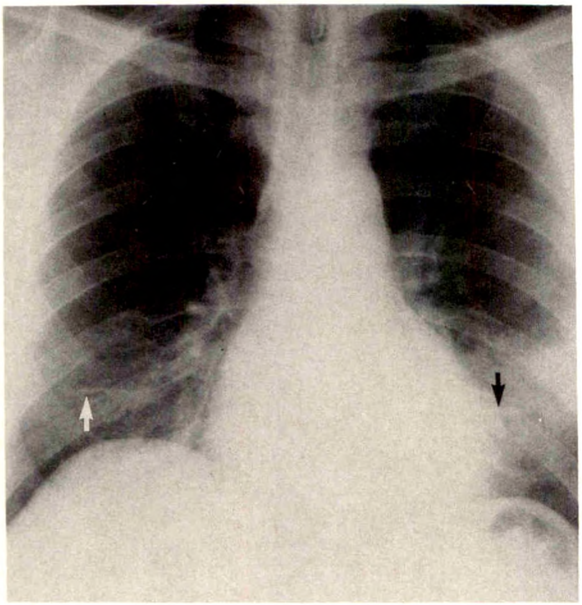


Figure 5. Chest radiograph of a patient with pneumonia due to *Chlamydia psittaci* showing bilateral basal linear opacities in the lower zones (arrowed). These are indistinguishable from those occurring with pneumocystis pneumonia.

areas of collapse, although no confirmatory pathological information is available from either our cases or the literature. Small lung volumes and impaired diaphragmatic movement predispose to the development of small areas of collapse, and in our patients, lung volume judged from diaphragm position was significantly small in patients with linear opacities. Clinically, rapid, shallow respiration is a recognized feature of pneumocystis pneumonia (Falkenbach et al, 1961; Epstein et al, 1982; Gamsu et al, 1982). Why this should be remains unclear, but reduced lung compliance may be a factor. Pleuritic pain which would inhibit diaphragmatic movement is not a typical finding in pneumocystis pneumonia.

Small areas of atelectasis may be seen on the chest radiograph following BAL due to local retention of lavage fluid. Broncho-alveolar lavage had been performed in seven patients in all in the series. Of the nine episodes of pneumocystis pneumonia in which linear opacities were seen, BAL had been performed in only two instances. In one case the lines appeared eight days before BAL and therefore lavage cannot be implicated in the pathogenesis. However, on the other occasion, lines first appeared on the chest radiograph two days following BAL and the possibility that these may be the result of local retention of wash fluid cannot be excluded.

Cytomegalovirus was isolated in six patients at the time of the acute illness. This is a common finding in HIV positive individuals and CMV and *Pneumocystis carinii* often occur together (Gamsu et al, 1982; Vanley et al, 1982). Linear opacities were seen in only one of these episodes and, as far as the authors are aware, linear opacities have not been described in CMV infection.

Linear opacities have been reported in other pneumonias (Fig. 5), notably as a result of *Mycoplasma pneumoniae* (George et al, 1966; Putman et al, 1975; Finnegan et al, 1981) as well as with *Chlamydia trachomatis* (Edelman et al, 1984) and *Chlamydia psittaci* (Fraser & Paré, 1978). Segmental atelectasis is also known to be a finding in *Legionella pneumophila* infection (Dietrich et al, 1978; Fairbank et al, 1983). As is the case with *Pneumocystis carinii* pneumonia, the presence of linear opacities is not well documented in these pneumonias. Atelectasis is reported in approximately 10% of Mycoplasma infections (George et al, 1966) and in 4–8% of Legionella infections (Dietrich et al, 1978; Fairbank et al, 1983). Our own experience suggests that the prevalence of linear opacities in pneumonias other than *Pneumocystis carinii* infections is of the order of 9%. This is well below the 41% we recorded. Although the present series is small, it does suggest that such linear opacities, although non-specific, are significantly more frequent in *Pneumocystis carinii* than in other pneumonias, and as such, the presence of linear opacities in a patient with an atypical pneumonia should raise the possibility of pneumocystis infection.

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Percutaneous femoral artery puncture: practice and anatomy

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Abstract. In a survey of the superficial landmarks used to select the site of puncture of the femoral artery for angiography, the inguinal skin crease was most popular, preferred by 39.2% of angiographers. The maximal femoral pulse irrespective of the position of the skin crease was the next most popular landmark (24.7%). Bony landmarks were least popular (13.0%). The majority (73.7%) of those using the skin crease punctured at the same level or distal to it. The relationship of these superficial landmarks to the common femoral artery (CFA) and its bifurcation were investigated. The inguinal skin crease was distal to the bifurcation of the CFA in 71.9% of limbs (mean, 0.61 cm). The maximal femoral pulse was over the CFA in 92.7% of limbs, and the CFA was projected over the medial aspect of the femoral head in 77.9% of limbs. The use of the inguinal skin crease is a popular though unreliable guide for puncture of the CFA. Use of the maximal femoral pulse will enable more constant puncture of the CFA.

Since its introduction (Seldinger, 1953), percutaneous puncture of the femoral artery has become the commonest means of access to the arterial system for diagnostic and interventional procedures.

The common femoral artery (CFA) is considered by many angiographers to be the safest site for arterial puncture as it lies for much of its course over bone against which it can be easily compressed to achieve haemostasis. It has a larger diameter than the superficial femoral artery (SFA) or profunda femoris (PF) making it more suitable for the passage of large catheters and sheaths, particularly during complex interventional procedures. Several reports have emphasized that local arterial complications, especially pseudoaneurysm, arteriovenous fistula and thrombosis are commoner following puncture of the SFA or PF than after puncture of the CFA (Rapoport et al, 1985; Cole & Krone, 1987; Altin et al, 1989).

There is little published data relating the CFA and its bifurcation to the landmarks used to guide puncture level. The inguinal skin crease has been shown to be distal to the bifurcation of the CFA in 75% of limbs, but other landmarks were not considered (Lechner et al, 1988).

We reviewed the landmarks used by angiographers to select puncture level and investigated the relationship of the CFA to the anatomical landmarks used by angiographers to puncture the femoral artery.

Material and methods

Questionnaires were sent to 100 consultant radiologists (52) and cardiologists (48) who perform angiography.

Details were sought of the methods and landmarks used to select level of puncture in the groin.

The positions of the superficial landmarks were investigated in patients undergoing diagnostic transfemoral lumbar aortography. Both skin creases and sites of maximum pulse were marked with metallic devices and a ruler was positioned over the lower abdominal wall permitting measurements corrected for radiographic magnification.

The control radiographs displaying these markers were then related to the subsequent angiograms demonstrating the underlying arterial anatomy. The position of the inguinal ligament was taken to be the line between the anterior superior iliac spine and pubic tubercle, bony landmarks that can be palpated in the angiography suite.

Results

The response rate to the questionnaires was 75%.

Details of the landmarks for the preferred site of puncture are given in Table I. The most popular single landmark was the inguinal skin crease (39.2% overall). The majority of angiographers using this landmark (73.7%) punctured at or below the level of the skin crease (Table II). The level of the strongest femoral pulse was the next most popular site (24.7%). Bony landmarks were least popular.

One hundred and twenty-three limbs in 73 patients were studied. In 23 limbs a femoral pulse was not palpable.

Table I. Landmarks used for femoral puncture

Landmark	Total number	(%)
Skin crease	27	(39.2)
Maximum pulse	17	(24.7)
Bone	9	(13.0)
Crease/pulse	9	(13.0)
Crease/bone	1	(1.4)
Pulse/bone	5	(7.3)
All three	1	(1.4)
Total	69	(100)

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*Author for correspondence.

Table II. Relation of puncture site to skin crease

Site	Total number	(%)
Same level	10	(26.3)
Lower	18	(47.4)
Higher	8	(21.1)
Not specified	2	(5.2)
Total	38	(100)

The results of measured relationships are shown in Fig 1.

The marker of maximal femoral pulsation was projected over the CFA in 92.7% of limbs, the SFA in 4.9% and the bifurcation in 2.4%.

Maximal pulsation was projected over the medial aspect of the femoral head in 77.9%, the medial aspect of the femoral neck in 9.1%, the superior pubic ramus in 6.5%, and the inferior pubic ramus in 6.5% of all limbs.

The bifurcation of the CFA was proximal to the inguinal skin crease in 71.9% of limbs and distal in the remainder. Its mean position was 0.61 cm proximal to the inguinal skin crease.

Discussion

Transfemoral catheterization procedures are comparatively safe with a low incidence of complications. In large series there is a puncture site complication rate of between 0.11–0.47% (Chiverton & Murie, 1986; Millar, 1986). Such complications include haemorrhage (0.26%), arterial thrombosis (0.14%), pseudoaneurysm (0.05%) and arteriovenous fistula (0.01%) (Hessel et al, 1981).

Local complications depend on many factors such as age of patient, state of peripheral vasculature, type of procedure, anticoagulation, and also the technique of arterial puncture and subsequent haemostasis.

"High" puncture of the femoral artery is considered to increase the risk of extraperitoneal bleeding, and for this reason a "low" puncture site using the skin crease has been advocated (Reuter & Redman, 1977).

However, several reports have emphasized that there is a greater incidence of pseudoaneurysm, arteriovenous fistula and thrombosis when the SFA and PF is punctured, and have suggested that these are less likely to occur if the CFA is used (McMillan & Murie, 1984; Cole & Krone, 1987; Altin et al, 1989). This may be because of difficulty in adequately compressing the SFA and PF compared with the CFA, which lies for most of its length over bone (femoral head and pubic ramus).

As some procedures require the use of very large calibre sheaths (up to 16F for mitral valvoplasty), it is especially important to puncture the CFA as the smaller SFA or PF may be occluded during the procedure.

Our results suggest that a "low" approach at the inguinal skin crease is more likely to puncture the SFA or PF even allowing for upward angulation of the needle.

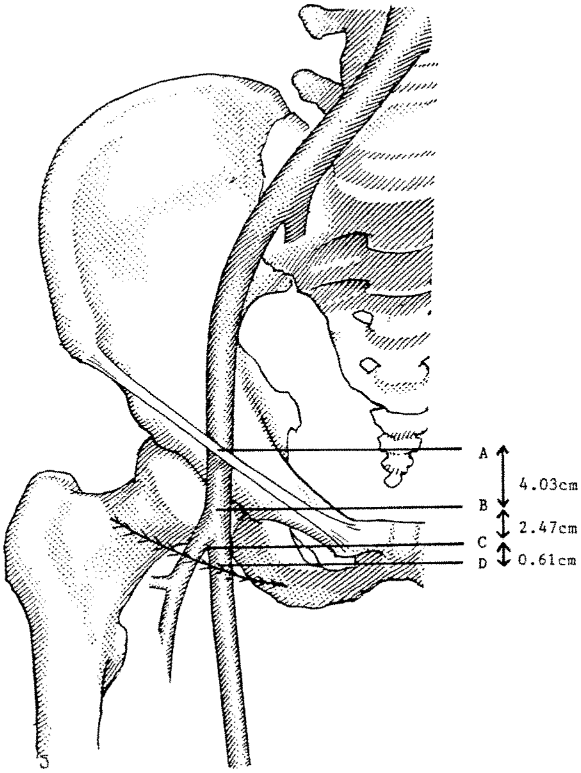

Figure 1. The relationship of the femoral artery to the superficial landmarks used at angiography. (A: inguinal ligament; **B**: maximal femoral pulse; C: bifurcation of common femoral artery; D: inguinal skin crease.)

It has recently been shown that the position of the inguinal skin crease is particularly variable, especially in obese patients, and that the bifurcation of the CFA is at a higher level in over 75% of cases (Lechner et al, 1988). Our results agree with these findings; the skin crease being distal to the bifurcation in 71.9% of limbs. This figure may be an underestimate as in some cases the bifurcation may appear to be more distal on antero-posterior radiographs than it is in reality.

We confirmed the findings of others (Dotter & Rosch, 1978) that in the majority of limbs, 77.9% in our series, the CFA was projected over the medial aspect of the head of the femur.

The increasing use of larger catheters and sheaths for interventional procedures means that the technique of percutaneous femoral arterial puncture will become more critical if local complications are to be avoided. The CFA is larger than the SFA and is the optimal vessel to use for transfemoral procedures. The level of the maximal pulse irrespective of the position of the skin crease is the most reliable guide to its accurate puncture. The skin crease, though the most popular landmark amongst angiographers, is less reliable in this respect.

Acknowledgment

We would like to thank those angiographers who replied to our questionnaire.

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Hepatic imaging with computed tomography of chronic tyrosinaemia type 1

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Abstract. Tyrosinaemia type 1 (fumaryl acetoacetase deficiency, hepato-renal tyrosinaemia) is a rare inborn error of metabolism which, in its chronic form, leads to cirrhosis in early childhood and subsequent development of hepatocellular carcinoma in a high proportion of cases. Imaging with computed tomography has an important role in assessing the progress of the liver disease and may be helpful in timing liver transplantation. The radiological features of seven cases are described and the implications discussed.

Tyrosinaemia type 1 is an autosomal recessive disorder that is rare in the UK, although there is a higher incidence in the Canadian province of Quebec and parts of Scandinavia. The basic defect is deficiency of fumaryl acetoacetase (Lindblad et al, 1977; Fallstrom et al, 1979; Kvittingen et al, 1981), the last step of the catabolic pathway of tyrosine, which has been demonstrated in hepatocytes, skin fibroblasts, lymphocytes and also amniocytes, so that prenatal diagnosis is possible (Kvittingen et al, 1985). As a result of the enzyme defect, the patients excrete succinyl acetone, and other characteristic metabolites derived from maleyl, and fumaryl acetoacetate.

The cardinal clinical features of tyrosinaemia type 1 are progressive liver disease and renal tubular abnormalities. However, there is a broad spectrum of severity. In the acute form of the disease, usually seen in early infancy, the patients may die of fulminant hepatic failure, (Goldsmith, 1983). Others may present in early infancy or childhood with failure to thrive, hepatosplenomegaly and rickets secondary to chronic liver disease and the renal tubular disorder. A diet low in the amino acids tyrosine, phenylalanine and methionine will improve liver and renal function but does not prevent continuing liver damage. Cirrhosis usually becomes established in early childhood, and there is a high risk of hepatocellular carcinoma (HCC) during childhood or later. Although published studies only give a risk of approximately 40% (Weinberg et al, 1976), the risk with long term follow-up is probably much higher, and may even be close to 100%.

The role of diagnostic imaging is to follow the progress of liver disease, and particularly to detect possible pre-malignant or malignant change at the earliest stage.

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Patients and methods

Between 1982 and 1988, 10 patients with hereditary tyrosinaemia were seen at the Hospital for Sick Children, London; the age at presentation ranging from birth to 6 years. The diagnosis was confirmed in all patients by specific assay of succinyl acetone using gas-chromatography—mass spectrometry (Pettit et al, 1984) and confirmed by enzyme assay (Kvittingen, Oslo). All the patients were treated with low tyrosine diets and appropriate vitamin and mineral supplements. Three children died in the first year of life from hepatic failure and are not included in the series. Seven children have been examined radiologically. Computed tomographic (CT) scans of the liver before and after intravenous contrast medium administration were performed on all patients on an EMI 500S or Toshiba 60A scanner, with a total of 12 examinations.

Four children underwent hepatic transplantation and pathological features were correlated with CT images. One patient had a hepatic transplantation abroad and histology is not available for review.

Results

Our results are summarized in Table 1. The appearances of the liver can be divided into three groups with specific patterns of attenuation. In Group 1 the liver is of normal attenuation, or diffuse low attenuation (Fig. 1). In Group 2 the liver has a mixed background attenuation with high attenuation nodules. These nodules may vary in size from subtle, small nodules of 2–3 mm in diameter (Fig. 2) to more prominent nodules of 1–2 cm in diameter (Figs 3 and 4). In the third group, the changes in the liver again consist of a mixed background attenuation with high attenuation nodules but with, in addition, larger low attenuation nodules (Figs 5 and 6).

Three patients show the features of Group 1. In two cases the liver was of normal attenuation: Patient 1 is still well, and, in Patient 2, the appearances of the liver

Table I. Computed tomographic features in hereditary tyrosinaemia

Patient	Age at time of scan	Attenuation of hepatic parenchyma	Attenuation of hepatic nodules if present	Nephrocalcinosis	Histology	Clinical outcome
1	6 years	Normal	Absent	Absent	Not available	Patient alive and well
2	1 month	Normal	Absent	Absent		
	4½ months	Normal	Absent	Absent		
	11 months	Mixed	High	Absent	Macronodular cirrhosis	Transplanted — good result
3	5 months	Low	Absent	Absent	Not available	Patient has chronic liver disease
	17 months	Mixed	High	Present		
4	10 months	Mixed	High	Absent	Macronodular cirrhosis	Transplanted — good result
5	16 months	Mixed	High	Absent	Not available	Transplanted abroad
6	6 years	Mixed	High	Present	Macronodular cirrhosis with multinodular hepatocellular carcinoma	Transplanted but lung secondaries have developed
	7 years	Mixed	High with large low attenuation nodules	Present		
7	5½ years	Mixed	High and low attenuation nodules	Present	Macronodular cirrhosis and multinodular hepatoma	Transplanted, developed a local recurrence and lung secondaries and died

have changed and now show mixed attenuation with high attenuation nodules. Similarly, Patient 3 initially showed diffuse low attenuation of the liver which has changed to show mixed background attenuation and high attenuation nodules.

In all, five patients show the features of Group 2 with high attenuation nodules and mixed background attenuation on CT. Four livers were available for histological examination. The results in two cases (Patients 2 and 4) showed macronodular cirrhosis. In two patients the results of histology was not available; Patient 3 has chronic liver disease and Patient 5 has had a successful transplant abroad.

Two patients (6 and 7) show the features of Group 3 with large low attenuation nodules superimposed on the above changes and had multifocal HCC in the resected liver. In Patient 6 a progression of the changes from Group 2 to those of Group 3 was seen on CT.

Three patients showed nephrocalcinosis.

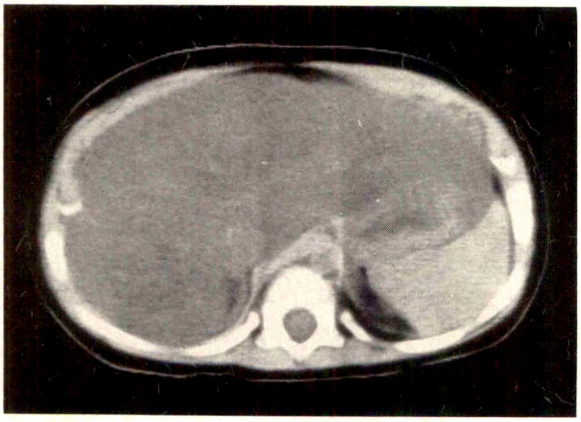

Figure 1. *Patient 3.* Diffuse low attenuation seen in early disease.

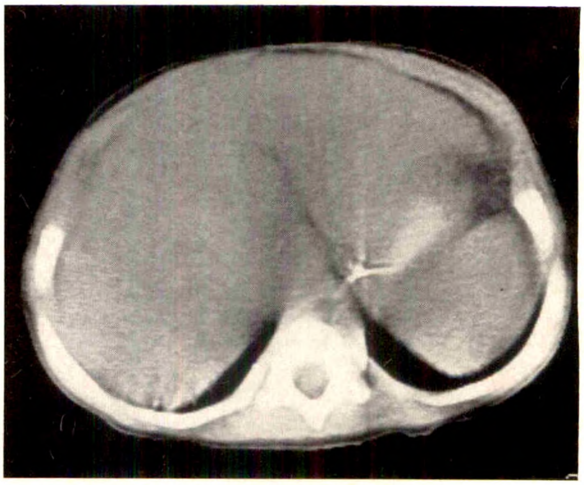

Figure 2. *Patient 2.* Small high attenuation nodules are seen in a mixed attenuation parenchyma.

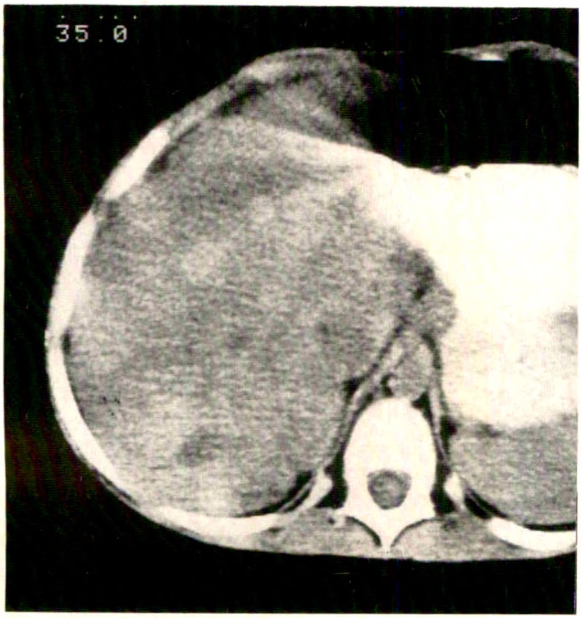

Figure 3. *Patient 6.* High attenuation nodules are seen throughout the liver.

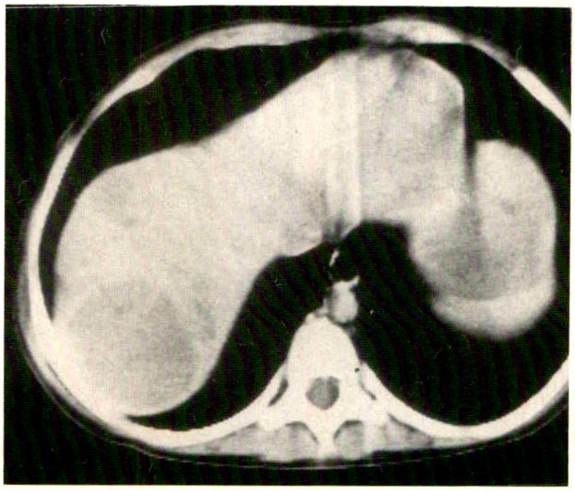

Figure 5. *Patient 6.* The large low attenuation nodules not present on CT a year earlier were shown on histological examination to represent HCC.

Discussion

Tyrosinaemia type 1 presenting in childhood is probably uniformly fatal. In the early months, death may result from liver failure or uncontrollable bleeding. Later, the major cause of death is HCC. Although both the liver disease and the renal tubular abnormalities will improve with dietary treatment and appropriate supplements of vitamin D and phosphate, liver damage continues. It is probable that a high proportion will develop HCC and the only curative treatment is liver transplantation. This has been successfully carried out on patients with tyrosinaemia type 1 and corrects most of the biochemical sequelae, although the patients continue to excrete small quantities of succinyl acetone (Fisch et al, 1978; Starzl et al, 1985; Van Thiel et al, 1986). Although some patients have had successful transplants once they have HCC, there is a high risk of recurrence. Thus it is very important to aim to transplant before malignancy develops. Biochemical markers are of little use, and in particular serum alpha-feto protein is not helpful in these patients. The values in most patients are markedly elevated and, although they usually decline slowly, it is not satisfactory to wait until levels rise because the tumour will by then already be present. Radiological imaging has a key role in the assessment of the rate of progress of the liver disease and the timing of surgery.

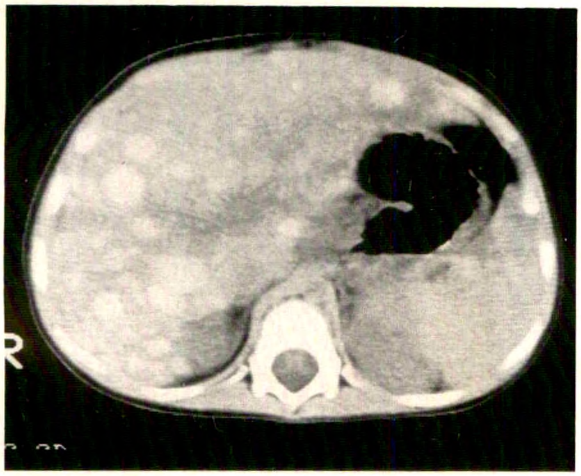

Figure 4. *Patient 3.* The high attenuation nodules represent progression of disease over 12 months.

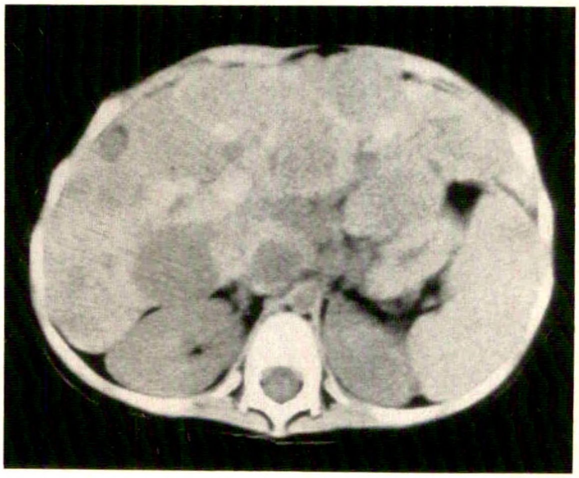

Figure 6. *Patient 7.* Multifocal HCC on a background cirrhosis seen on CT and in the resected liver.

We have found CT imaging to be useful in our patients.

The changes of cirrhosis of the liver are well shown by CT scanning. Regenerating nodules are characteristically of low attenuation or isodense with surrounding liver (Stanley et al, 1977). However, regenerating nodules in hereditary tyrosinaemia have been noted to show high attenuation (Day et al, 1987), as we have found in six of our patients. The detection of tumour in pre-existing cirrhosis is acknowledged to be a difficult problem. Hepatocellular carcinoma is usually of low attenuation on CT relative to surrounding liver, although calcification may be present. Intravenous contrast medium administration does not always make identification of the tumour easier (Itai et al, 1979; Kunstlinger et al, 1980).

Our results demonstrate some important features. The appearances of the liver on CT fall into three groups which correlate with varying clinical severity of the disease and specific histological changes.

In patients with mild or early disease (Patients 1 and 2), the CT may be normal with normal liver attenuation. Diffuse low attenuation, which we presume represents fatty change can also be seen early in the disease (Patient 3, Fig. 1). A later change is one of mixed background attenuation and high attenuation nodules and this correlates histologically with the presence of macronodular cirrhosis (Patients 2 and 4, Figs 2, 3 and 4). Lastly, the development of low attenuation nodules correlates with the presence of multinodular HCC (Patients 6 and 7, Figs 5 and 6). Three of our patients had more than one CT scan and demonstrated a progression of changes from normal liver attenuation through to mixed attenuation with high and subsequently low attenuation nodules (Patients 3 and 6) and we suggest that this parallels the clinical course of the disease.

We conclude that CT is a reliable technique for documenting the progress of liver disease in tyrosinaemia type 1 and that progress appears relentless but probably fairly predictable. Although CT can detect the development of HCC, pathological examination of the excised liver suggests that the extent of cirrhotic and malignant change is underestimated. In two patients transplantation was performed when radiological evidence of HCC was present and they both subsequently developed lung secondaries. We consider that once the radiological changes of cirrhosis and regenerating nodules are present, transplantation should be carried out before there is evidence of malignant change. However, we do not know whether malignant change can arise in liver without detectable changes of cirrhosis and regenerating nodules. This makes it particularly difficult to decide on the timing of transplantation in those with mild disease.

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Quantitative microfocal radiography of children with renal osteodystrophy; comparison with laboratory and histological findings

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Abstract. High definition microfocal radiography permitted the quantitative assessment of the radiographic features of renal osteodystrophy in the phalanges of 11 children in stable chronic renal failure, treated with phosphate binders for 1 year. The most consistent feature was subperiosteal cortical resorption, expressed as a ratio total length of resorbed subperiosteal bone/total length subperiosteal bone × 100. It was found that the extent of resorbed bone was significantly greater in the middle phalanx and on the ulnar surface of the phalanges. The radiological findings over the duration of the disease were compared with laboratory assessments and bone histomorphometry. The extent of the percentage of subperiosteal resorption at base line and its change during the study period correlated significantly with the level of serum parathyroid hormone levels and its change over the same period. No other significant correlations were found between radiographic features and laboratory assessments or with bone histomorphometry.

Renal osteodystrophy is common in children with chronic renal failure and secondary hyperparathyroidism. The radiographic feature characteristic of this condition is subperiosteal resorption of the phalangeal margins, especially those of the middle and more particularly on the radial (lateral) than ulnar (medial) sides of these bones (Meema et al, 1978; Genant & Resnick, 1988). Other radiographic changes include periarticular erosions in the phalanges, erosions at the terminal phalangeal (ungual) tufts and increased cortical striations (Stanbury, 1967; Sundaram et al, 1979, 1980; Wilson & Genant, 1979; Bedani et al, 1985; Gerber et al, 1987). The latter, although associated with hyperparathyroidism (Meema et al, 1978; Wilson & Genant, 1979) and renal osteodystrophy (Meema & Meema, 1972) has also been seen in normal young adults and children undergoing a pubertal growth spurt (Meema & Meema, 1972; Wilson & Genant, 1979). For this reason, and because of the difficulty of standardizing the measurement of cortical striation (Meema & Meema, 1972), this feature was not assessed in this study.

At this hospital, earlier studies have shown that secondary hyperparathyroidism could be suppressed in children with chronic renal failure by using a regimen of mild dietary phosphate restriction with a high dose of phosphate binders (Mak et al, 1985). The bone histomorphometry of these patients investigated over the period of the study showed a general improvement (Turner et al, 1988). At the same time, high definition microfocal radiographs (Buckland-Wright, 1989; Buckland-Wright & Bradshaw, 1989) were obtained of the wrists and hands of these patients. Accurate measurement of the dimensions of the features recorded on the macroradiographs can be obtained (Buckland-Wright et al, 1986) and provide details of their extent and progression (Buckland-Wright & Walker, 1987; Buckland-Wright et al, 1989).

In this study of children with renal osteodystrophy the extent of the different radiographic features was determined, where possible, by methods of measurement independent of the effect of growth. The findings were compared with laboratory assessments and bone histomorphometry.

Patients and methods

Eleven children, aged 5–15 years (mean 10.2 ± 3.2 years) in stable chronic renal failure were studied (disease duration mean 5.3 ± 4.3 years). Both mild renal insufficiency and severe chronic renal failure were represented with glomerular filtration rates varying from 8–45 ml/min/1.73 m^2. There was no change in renal function during the 1 year period of the study (Mak et al, 1985). Clinical data and details of the treatment are published elsewhere (Mak et al, 1985) and are summarized below.

Macroradiographs were taken to coincide with the initial transiliac 8 mm Bordier trephine bone biopsy taken after the patients had been without phosphate

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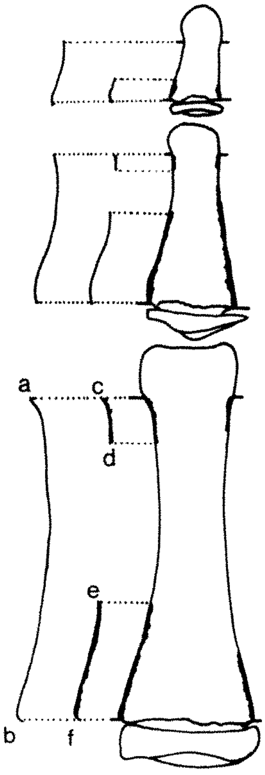

Figure 1. Diagram of the macroradiographic appearance of subperiosteal bone resorption in the phalanges. Length a–b is the subperiosteal length, lengths c–d and e–f the subperiosteal resorption length.

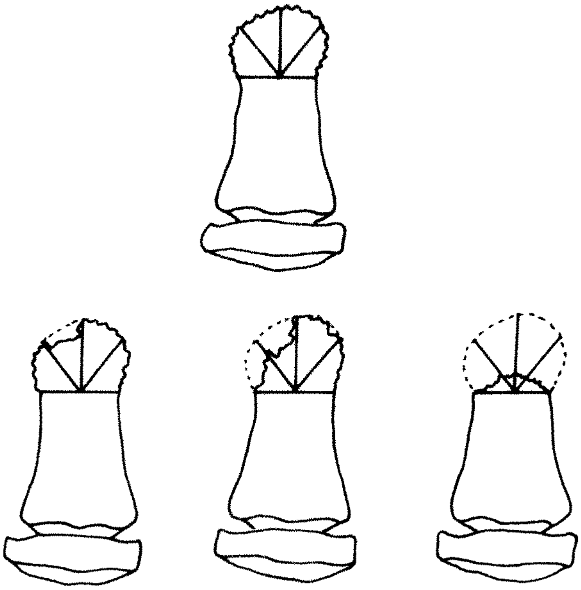

Figure 2. Diagram of terminal phalangeal (ungual) tuft. Refer to text for the method of scoring the extent of ungual erosions.

binders for 3 months (Mak et al, 1985) and with the bone biopsy taken after the patients had been taking high doses of phosphate binders for 12 months (6 months on aluminium hydroxide and 6 months on calcium carbonate, randomly allocated) with mild dietary phosphate restriction and vitamin D supplementation (Mak et al, 1985). Over the period of the study, values of serum immunoreactive parathyroid hormone (iPTH), calcium, phosphate, aluminium and routine biochemistry, were measured monthly and plasma 1,25-dihydroxycholecalciferol (DHCC) was measured every 3 months. Further details of these assays and the histomorphometric evaluation of the extent of bone resorption, have been described previously (Turner et al, 1988).

Stereopair macroradiographs (×5.2 magnification) were prepared of the right and left wrists and hands of each patient (Buckland-Wright, 1984, 1989). The hand was placed in a stereotaxic unit positioned close to the X-ray source and displaced by 6 mm between X-ray exposures (Buckland-Wright, 1989). The stereopair macroradiographs thus obtained were examined under a large format stereoscope for three-dimensional evaluation of phalangeal structure (Buckland-Wright & Bradshaw, 1989). A cross-wire cursor was used to outline the structures of interest in the macroradiograph overlying a back illuminated digitizer tablet linked to Video-MOP (Kontron Ltd). A detailed description of this method of measurement and its precision in recording radiographic features is reported elsewhere (Buckland-Wright et al, 1986). For this study precision was assessed by determining variations in the measurement of length. The coefficient of variation for this parameter was 3.7%. The data initially recorded on microcomputer discs were transferred to an IBM PC/AT. A standard format was used in this file for each patient/hand visit record, enabling comparison of data both within and between patients and visits. The analysis was carried out with the SPSS/PC+ statistics package (Norusis, 1986). The following radiographic features were measured.

Subperiosteal bone length

The total length of subperiosteal bone was measured on the medial and lateral sides of each of the phalanges of the second to fifth digits of both hands (Fig. 1, length a–b).

Subperiosteal resorption length

The length of subperiosteal cortical resorption was measured for the medial and lateral sides of each of the phalanges of the second to fifth digits of both hands (Fig. 1, lengths c–d and e–f). To overcome the effects of growth these measurements were expressed as the ratio subperiosteal resorption length/subperiosteal length × 100% and expressed as a percentage of subperiosteal resorption.

The extent to which phalangeal growth occurred during the study was determined from the change in

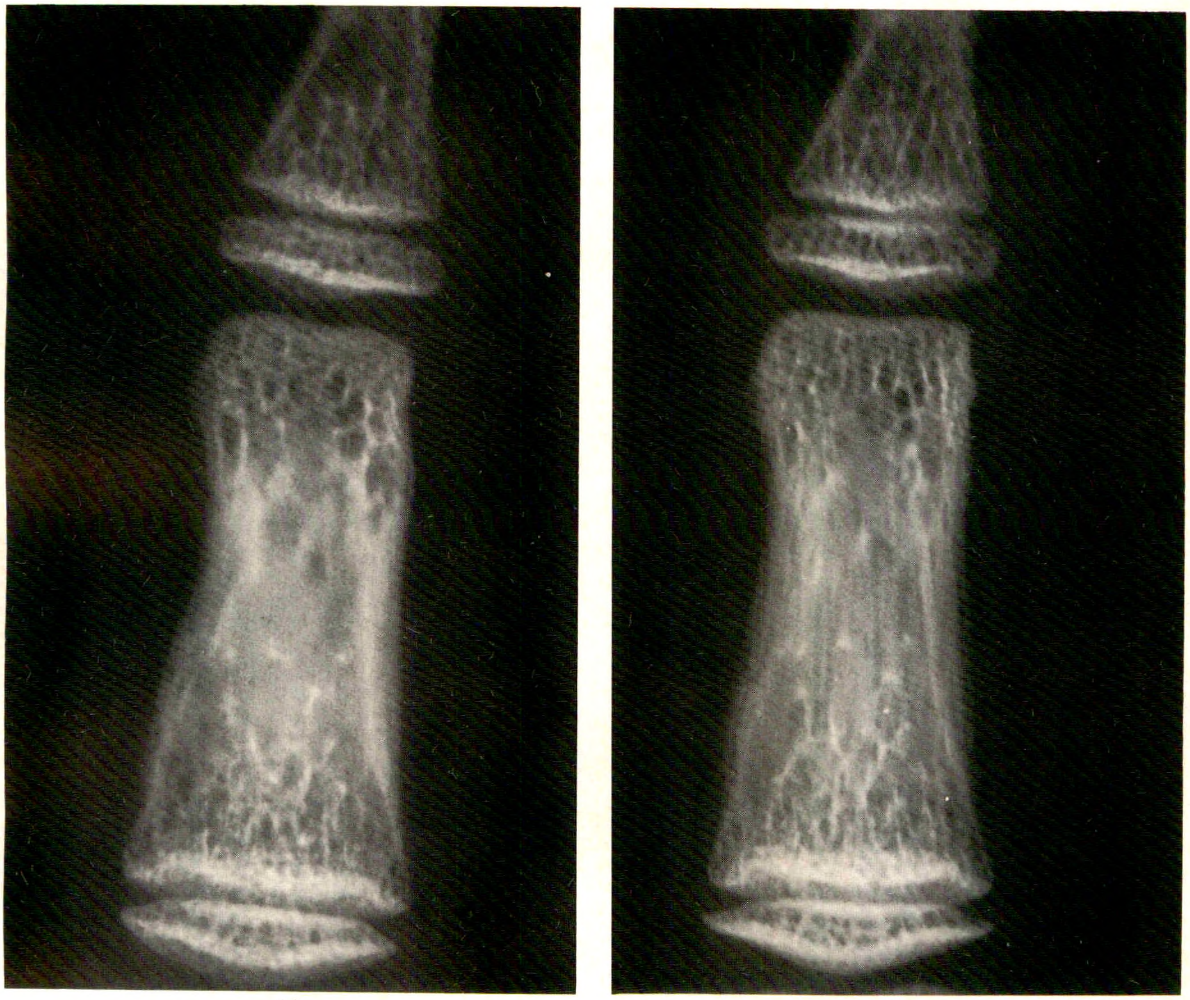
(a) (b)

Figure 3. Part of a macroradiograph of the middle phalanx of a child with renal osteodystrophy showing extensive subperiosteal resorption, particularly on the ulnar (left) surface (a). (b) One year later the extent of the resorption is significantly reduced. Note the increased cortical striation associated with the growth spurt. (Original magnification ×5.2, reproduced at ×4.4.)

subperiosteal length and the significance level determined using the single-tailed Wilcoxon matched pairs test. The extent of the percentage of subperiosteal resorption in the different parts of the hand was calculated, *i.e.* between the proximal, middle and distal phalanges, and between the radial (lateral) and ulnar (medial) sides of each of the phalanges at the initial and final X-ray visits as well as the change between the visits. The Wilcoxon matched pairs test was used to determine the significance of any difference, other than that between proximal, middle and distal phalanges where the Friedman two-way ANOVA test was used.

Erosion of terminal phalangeal (ungual) tufts

A transect was drawn perpendicularly to the base of the ungual tuft at each terminal phalanx. The margin of the tuft was divided into four equal regions (Fig. 2). Erosions occurring at the margin of any one of the regions scored 1 giving a total of 4 for all regions. Where the erosion extended into the tuft this scored an additional point for each region. When erosions were so severe that there was almost complete removal of the tuft this scored a further 2 points giving a possible total score of 10 points. This assessment was carried out on the terminal phalanges of the second to fifth digits of both hands. Stereoscopic examination of the macroradiographs of the wrists and hands was carried out to determine the presence or absence of periarticular erosions.

The percentage of subperiosteal resorption at the initial and final X-ray visit and its changes between the vists were compared with the laboratory data (Mak et al, 1985; Turner et al, 1988) and bone histomorphometric findings for these patients (Turner et al, 1988).

Table I. Mean (standard deviation) and significance of the change in the percentage of subperiosteoal resorption in the phalanges, serum iPTH levels and the trabecular resorption surface as a percentage of the total trabecular surface at the first visit and after 1 year

	Subperiosteal resorption (%)	Serum iPTH (ng/l)	Trabecular resorption surface
Initial visit	33.45 (16.88)	1235 (598)	6.39 (1.65)
Final visit	22.87 (15.08)	471 (288)	4.66 (1.33)
Significance of change	$p < 0.02$	$p < 0.003$	$p < 0.006$

Test used: two-tailed Wilcoxon matched pairs test.

Serum iPTH was also compared with bone histomorphometric parameters. The significance of any correlation between the radiological, laboratory and histomorphometric data was assessed using Kendall's tau C. The significance level for all tests was set at $p=0.05$.

This study was approved by Guy's Hospital Ethical Committee and informed consent was obtained from the patients and their parents.

Results

Subperiosteal resorption of cortical bone was observed in the phalanges of both hands in 10 out of 11 patients at the initial and final visit (Fig. 3). The mean subperiosteal bone length increased significantly during the 1 year of the study from 642±89 mm to 661.8±61.8 mm ($p=0.037$). The mean percentage of subperiosteal resorption decreased significantly over the same period ($p=0.02$) (Table I, Fig. 3).

Evaluation of the extent of percentage of subperiosteal resorption between the phalanges showed that it was greatest in the middle, followed by the distal and least in the proximal phalanges at both initial and final visits; these differences were significant ($p=0.007$). Comparison of the percentage of subperiosteal bone between the radial and ulnar sides of the phalanges showed that it was significantly greater on the ulnar (medial) surfaces, at both initial and final visits ($p=0.007$). There was no significant difference in the change in the percentage of subperiosteal resorption between the proximal, middle and distal phalanges or between the radial and ulnar surfaces of these bones, during the study period.

Ungual tuft erosions were present in only 6 of the 11 patients initially giving a mean ungual tuft erosion score of 154. By the last visit the number of patients with ungual tuft erosion increased to 7 giving an overall score of 155.

Periarticular erosions were not seen on any of the macroradiographs of either extremity.

Comparison of radiological, laboratory and histomorphometric data. At the start, there was a significant positive correlation ($p<0.04$) between the percentage of subperiosteal resorption and serum iPTH concentration. By the end of the study, there was no significant correlation. There was a highly significant positive correlation ($p<0.008$) between the change in the percentage of subperiosteal resorption and serum iPTH concentration over the study period.

There were no other significant correlations between the percentage of subperiosteal resorption and any other laboratory finding or the change in subperiosteal resorption and that in the other parameters over the study period. Furthermore, there were no significant correlations between either the percentage of subperiosteal resorption or the iPTH and the bone histomorphometric parameters at either the beginning or the end of the study. Nor were there any significant correlations between the changes in either the percentage of subperiosteal resorption or the iPTH and the changes in bone histomorphometric parameters in these patients over the 1-year period of the study.

Discussion

Measurement of the extent of the radiographic features characteristic of renal osteodystrophy and their change with time showed that the percentage of subperiosteal resorption is a sensitive parameter. During the study period the percentage of subperiosteal resorption decreased significantly, an improvement which corresponds with that previously reported for clinical, laboratory and bone histomorphometric findings of the same patients (Mak et al, 1985; Turner et al, 1988). This parameters' sensitivity is in large part due to its independence from the effects of growth, recorded here in the significant increase in subperiosteal bone length.

Evaluation of the differences in the relative lengths of subperiosteal resorption in the phalanges confirmed earlier observations of the greater involvement of the middle phalanges (Doyle, 1972; Meema et al, 1978). The percentage of subperiosteal resorption was less in the proximal than in the distal phalanges owing to the relatively larger subperiosteal length in the former. In addition, the percentage of subperiosteal resorption was greater on the ulnar (medial) than on the radial (lateral) side of the phalanges and is at variance with an earlier finding (Meema et al, 1978) which was based on standard radiographic examinations of adult patients. During the course of the study the pattern of subperiosteal resorption in the phalanges remained consistent, no part of the phalanges showed a greater or slower rate of repair than another.

Although erosions of the ungual tufts have been described in adults as the earliest indicator of renal osteodystrophy (Bedani et al, 1985; Sundaram et al, 1979, 1980), in children this feature was present to a variable degree in only seven of the 11 patients over the study period. It appeared that erosion of the ungual tufts was not a sensitive parameter in children compared with adults. Periarticular erosions were not observed in the macroradiographs of patients in this study, although they may be present in adults (Pugh, 1951).

The improvements in the radiographic appearance of the bone during the study confirm the earlier reports of the success of the treatment in these patients (Mak et al, 1985; Turner et al, 1988). This is supported by comparison between the extent of subperiosteal bone resorption and the laboratory findings. At the onset of the study, when all patients were hyperparathyroid, there was a significant positive correlation between the percentage of subperiosteal resorption and serum iPTH levels. A more highly significant correlation was obtained in the change between these two parameters during the study. By the end of 1 year, only three patients remained hyperparathyroid, which accounts for absence of significant correlation between the percentage of subperiosteal resorption and the reduced range in serum iPTH levels of the patients.

The absence of correlation between the percentage of subperiosteal resorption and 1,25-DHCC levels suggests that the lowered plasma concentration of this factor does not have as direct effect on bone metabolism as the raised levels of parathyroid hormone. The nearly constant plasma levels of calcium and phosphate in the patients throughout the study (Mak et al, 1985; Turner et al, 1988) would account for the lack of correlation between these factors and the percentage of subperiosteal resorption. The relation was investigated between the percentage of subperiosteal resorption and serum aluminium as subperiosteal resorption has been described as occurring in aluminium related bone disease in patients on renal dialysis (Sherrard, 1986) and as all the patients in this study received aluminium hydroxide during part of the study. The results showed no correlation. However, the strength of the correlation between the extent of subperiosteal resorption and serum iPTH indicates that in these patients this bony feature was related to the secondary hyperparathyroidism rather than aluminium toxicity.

Although no significant correlation was found between the radiographic parameters and any of the bone biopsy histomorphometric features, it is emphasized that the findings of the two techniques were consistent in showing the same directional change during the course of the study (Table I). The absence of any correlation was probably due to the radiographic and histological techniques examining the effects of secondary hyperparathyroidism in different regions of bone, *i.e.* the cortical and trabecular bone and to intraskeletal variations.

The findings of this study showed that the assessment of the percentage of subperiosteal resorption in children with renal osteodystrophy correlates significantly with the serum iPTH levels. This parameter accurately indicated the extent and progression of the condition and its response to treatment.

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Radiological definition of a new model of portal diversion in the rat

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Abstract. Diversion of portal blood away from the liver can be accomplished in the rat by two straightforward surgical procedures: subcutaneous transposition of the spleen followed later by portal vein ligation. This experimental model has great potential value in the study of liver cell transplants, porto-systemic shunts and hepatic porto-privation. Contrast medium radiology has been used to clarify and define the model further. Splenography, achieved by direct percutaneous puncture, demonstrated the developing spleno-subcutaneous vessels. Collaterals are seen as early as 3 days and appear extensive by 21 days after transposition. Almost all emanate from the convex outer surface of the spleen and course cranially and caudally in the subcutaneous tissues to drain into the subclavian and iliac veins. The appearance of these collaterals correlates well with survival after portal vein occlusion subsequent to splenic transposition. Direct portography demonstrates that, following portal vein ligation, contrast medium is diverted away from the liver into the splenic veins, through and around the spleen, before draining into the systemic circulation through spleno-subcutaneous collaterals. These radiological studies have demonstrated the changed circulatory pathways of this model of portal diversion and have confirmed that it is the splenic veins and the spleno-subcutaneous collaterals which are fundamental to its successful outcome.

Diversion of portal blood away from the liver can be accomplished experimentally in the rat by transposing the spleen subcutaneously and then transecting the portal vein 2–4 weeks later (Blumgart et al, 1971; McLachlan et al, 1971; Jaffe 1987). It appears, from direct observations and pressure measurements, that a new circulatory pathway is established in which portal blood is diverted across the pancreas and spleen before draining into the systemic circulation (Jaffe, 1987) (Fig. 1).

This "pancreatico-lienal" model of portal diversion has great potential value in the investigation of the effect of portal flow on the survival and growth of isolated liver cells within the spleen and pancreas. The model can be used to study the "porta-prived" liver. A spleno-systemic shunt system has, in effect, been established. This shunt could be made to include in situ intrasplenic liver cell implants.

The purpose of this study was to clarify and define this model of portal diversion further by radiological means. First, using direct splenography, the development and location of spleno-subcutaneous collaterals were demonstrated. Secondly, direct portography was used to monitor the changes which occurred following portal occlusion in animals which had undergone splenic transposition 4 weeks previously.

Method

Twenty-four male Wistar rats (Olac: 175–225 g) underwent subcutaneous transposition of the spleen (Fig. 1) in a manner similar to that originally described by Blumgart et al (1971). A few modifications were incorporated which included a fine scarification of the convex surface of the spleen and the corresponding subcutaneous tissue (Jaffe, 1987). To assess the development of collaterals radiological studies were performed immediately, 1, 3, 5, 7, 10, 14 and 21 days after transposition. Splenography was carried out under general anaesthetic by direct percutaneous splenic puncture with a 23 gauge butterfly needle using 2 ml of meglumine iothalamate 60% (Conray 280) by slow manual injection.

The effects of portal vein occlusion were then assessed by direct portography. Six animals which had undergone splenic transposition 4 weeks previously and four weight-matched unoperated controls underwent a laparotomy where a tributary of the caecal vein was isolated and cannulated using an operating microscope (Fig. 2). After obtaining direct portograms (Conray 280: 2 ml slow low pressure manual infusion) the portal vein was isolated at the liver hilus and soft-clamped. Post-occlusion portograms were then taken (Conray 280: 2 ml slow infusion) to outline the changed portal pathway. All four of the control animals died following portal occlusion. There was no mortality in the previously transposed rats.

A further eight animals had direct portography performed 24 h (four animals) and 2 weeks (four animals) after portal vein ligation and transection.

Exposure factors for all the radiographic studies were 50 kV, 3.2. mA, 100 cm FDD with high resolution screens.

Results

Direct splenography demonstrates the developing spleno-subcutaneous vasculature. Collaterals are seen as

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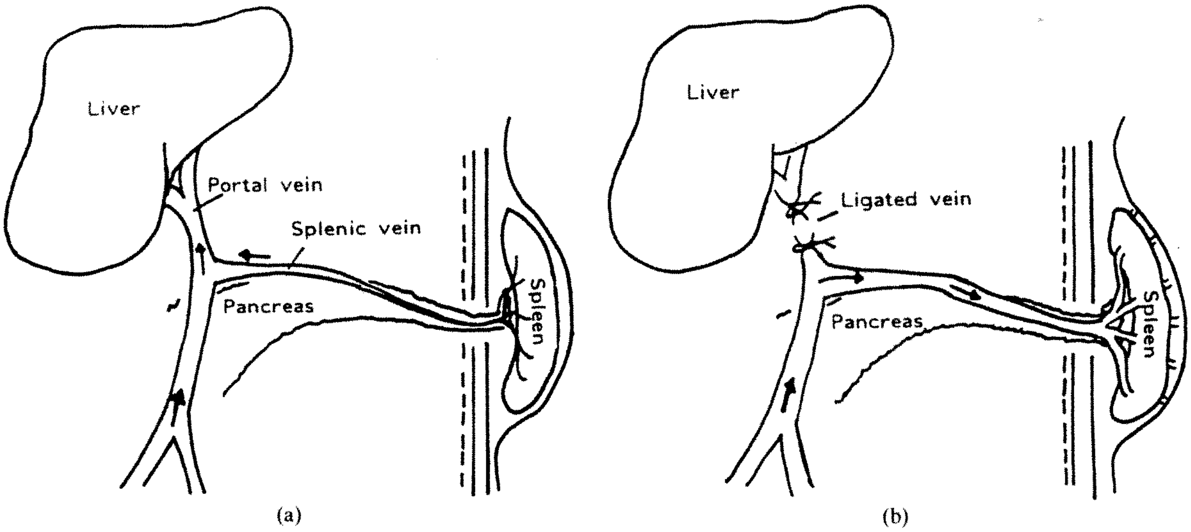


Figure 1. Diagrammatic illustration of (a) subcutaneous transposition of the spleen and (b) ligation of the portal vein at the liver hilus diverting portal flow across the pancreas and spleen.

early as 3 days, are numerous at 10 and 14 days after transposition and appear extensive by 21 days (Fig. 3). They almost all emanate from the convex outer surface of the spleen and course caudally in the subcutaneous tissue into the iliac veins. Cranially, veins drain both directly into the subclavian vein and to a lesser extent into the intercostal veins. The splenograms also outline the splenic vein and the intrahepatic portal system.

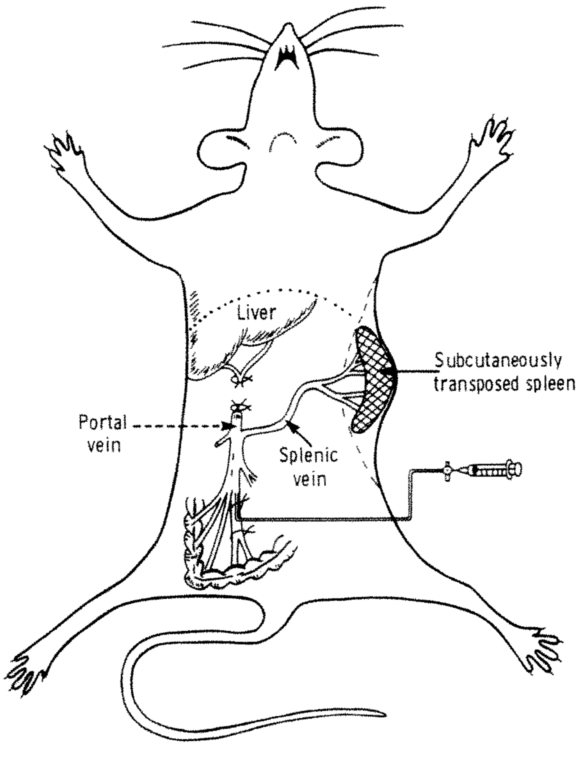


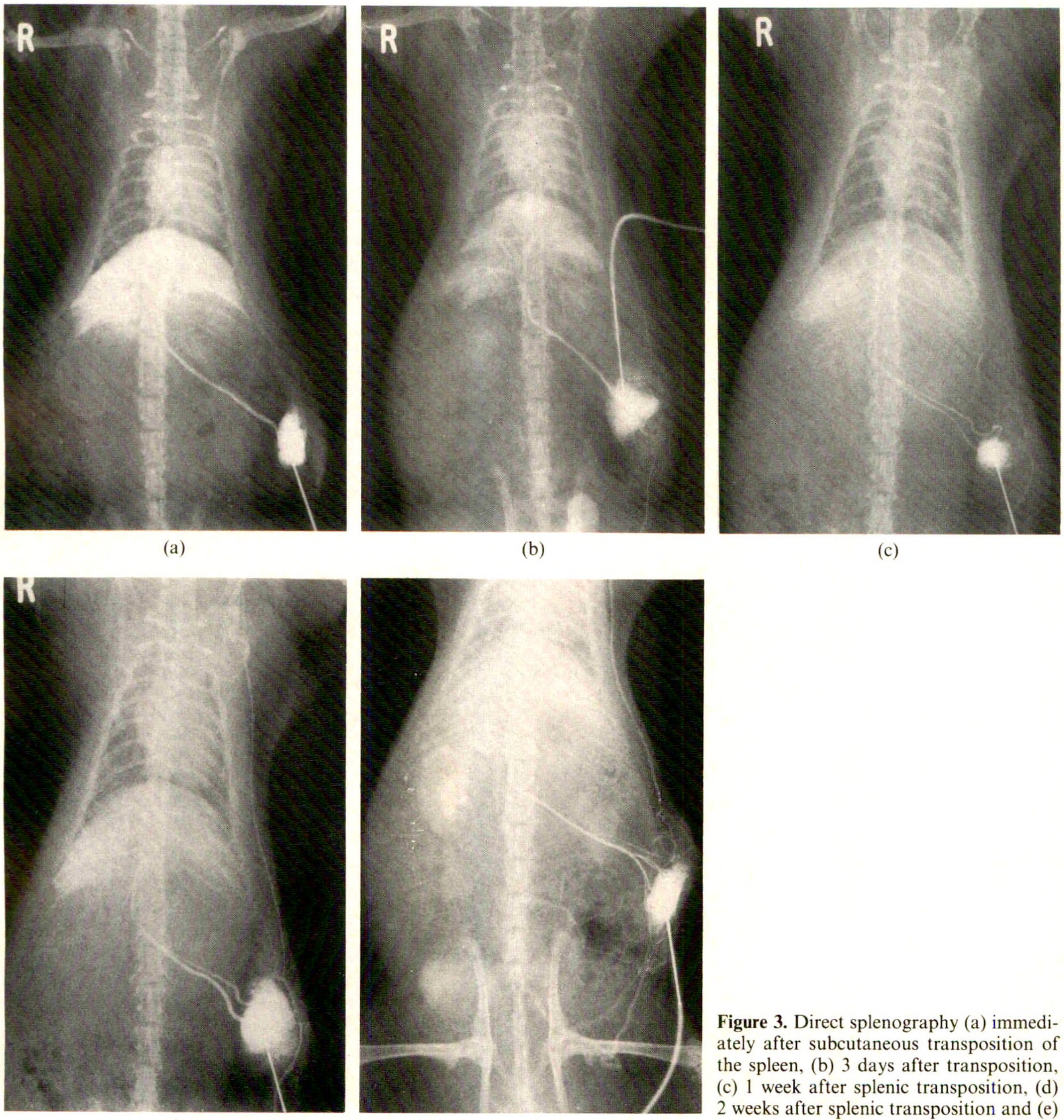
Figure 2. Cannulation of the caecal vein prior to direct portography.

Direct portograms taken before manipulation and in controls delineate the extra- and intra-hepatic portal venous system (Fig. 4a). Contrast medium is not seen to enter the splenic veins. Following portal occlusion the main portal vein is seen to dilate (Fig. 4b). The mean diameter of the vein (as measured at the level of L3 on the radiographs) was 0.75 mm pre-occlusion, 2.82 mm immediately post-occlusion, 2.3 mm 2 days post-transection and 2.23 mm 2 weeks post-transection. Contrast medium is shown to pass from the main portal vein into the splenic vein through and around the spleen to reach the spleno-subcutaneous collaterals and then finally into the systemic circulation.

Portography 24 h and 2 weeks (Fig. 4c) after portal vein transection outlines small "natural" portosystemic collaterals (*e.g.* gastric, inferior mesenteric) but demonstrates that, radiographically, the bulk of the contrast medium still passes retrogradely in the splenic vein to reach the systemic circulation.

Discussion

Surgical relocation of the spleen, which stimulates the formation of spleno-systemic collateral veins has been suggested as a method of reducing raised intra-portal pressure. Transposition of the spleen into the chest has been used both experimentally and clinically with some degree of success (Hoffman & Freedlander, 1960; Foster et al, 1961; Turunen et al, 1963) In all cases successful outcome is dependent on the development of collaterals from the surface of the spleen to the surrounding systemic tissue. Transposition of the spleen to a subcutaneous site in the rat was originally devised to facilitate



(a) (b) (c)

(d) (e)

Figure 3. Direct splenography (a) immediately after subcutaneous transposition of the spleen, (b) 3 days after transposition, (c) 1 week after splenic transposition, (d) 2 weeks after splenic transposition and (e) 3 weeks after splenic transposition.

intra-portal infusions (Bengmark et al, 1970). The surgical procedure is fairly easily accomplished with very low morbidity and mortality. However, the success of the model was frustrated by the development of collaterals which divert infusates into the systemic circulation. Despite modifications of the technique the development of collaterals, though delayed, is inevitable (McLachlan et al, 1971).

In the current model the aim was to stimulate formation of these porto-systemic collaterals by fine scarification. This modification of the transposition technique considerably reduces the mortality which follows portal transection (4 weeks later) (Jaffe, 1987). Direct splenography illustrates that fine needle deep scarification achieves this aim of promoting collateral formation: large veins are seen coursing from the spleen as early as 7 days after transposition. The rate at which these collaterals develop corresponds well to the survival figures for portal transection at various intervals following transposition with scarification (Jaffe, 1987).

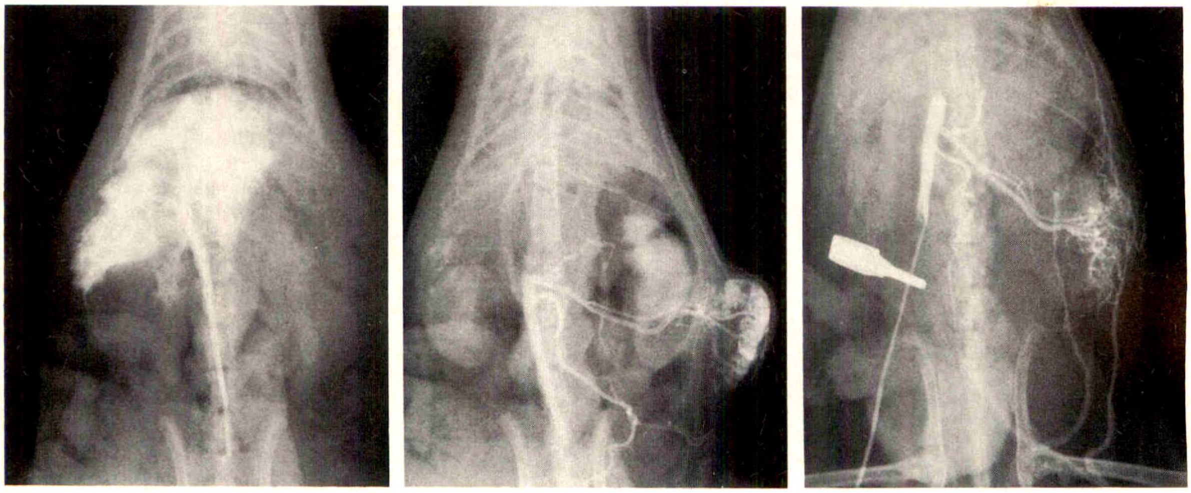

(a) (b) (c)

Figure 4. Direct portography: (a) splenic transposition only, (b) immediately after occlusion of portal vein at liver hilus and (c) 2 weeks after portal vein ligation and transection.

There is a high mortality rate after transection in the first 10 days but this rate rapidly falls as the interval between procedures increases.

It is of interest that in the current study large cranial collaterals have often been demonstrated draining directly into the subclavian vein (rather than via intercostal veins as seen in the Bengmark model). This difference may be a result of the subcutaneous tissue scarification which may open up more superficial vascular planes.

Occasionally collaterals develop inside the peritoneum between the pancreas or hilar surface of the spleen and adjacent adherent structures. It is presumed that, in general, new collateral formation reflects surgical trauma. In this model great care is taken to minimize this trauma inside the peritoneal cavity to ensure that portal diversion is across the spleen and pancreas.

Direct portography, in the rat, is fairly easily accomplished by cannulation of a caecal vein tributary. This vein is chosen, in preference to the more traditional gastroduodenal vein, because of its remoteness from the hepatic hilum. The superior mesenteric and portal veins as well as the origin of the splenic vein can be clearly outlined, the contrast medium filled cannula being situated well away from the area of special interest.

When the portal vein is occluded contrast medium is seen to flow retrogradely within the splenic vein. This flow reversal does not result from contrast medium infusion during direct portography because identical infusions in control (*i.e.* non-transposed) and pre-occlusion animals do not outline the splenic vein. It appears likely that hepatofugal flow in the splenic vein is due to the newly formed spleno-subcutaneous collaterals which provide a low resistance oulet into the systemic circulation.

The new circulatory pathway appears to stabilize over a period of about 24 h. Portal pressure returns to near normal levels (Jaffe, 1987) and other naturally occurring portosystemic collaterals open up (gastric and inferior mesenteric vein tributaries). From radiographs taken at 24 h and 2 weeks after transection it appears that the bulk of portal flow passes via the splenic compartment. However, if there has been significant surgical trauma at other sites, large collateral systems may develop there.

Direct observation and macroscopic radiology suggest that portal blood passes in large volumes through and around the spleen and pancreas. Furthermore, under the operating microscope the fine venous vasculature of the pancreas remains dilated well after the rest of the mesenteric circulation has returned to normal following the short period of portal hypertension. However, the true portal perfusion of the parenchyma of the spleen and pancreas at a microscopic level cannot be evaluated by these contrast media techniques. An assessment of parenchymal portal perfusion is therefore being currently made in a separate study using radiolabelled microspheres.

This study has demonstrated the development of spleno-subcutaneous collaterals following splenic transposition with scarification. The time course of collateral development correlates well with the improving survival figures as the interval between transposition and portal vein transection increases. Direct portography both at the time of portal occlusion and at later dates has further defined the changed circulatory pathways and confirmed that retrograde flow in the splenic vein is central to the success of this model of portal diversion.

Acknowledgments

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Transforming growth factor beta: a promotor of late connective tissue injury following radiotherapy?

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Abstract. Transforming growth factor beta (TGF-β) is a peptide which has a fundamental role in controlling proliferation of many cell types. Its main effect upon connective tissues *in vivo* is to stimulate growth. It can result in endothelial cell proliferation but tends to inhibit epithelial cell growth. Damage to the connective tissues and the vasculature are the principal findings in late radiotherapy damage. Following the initial cellular depletion after radiotherapy, an abnormal proliferation of these tissues occurs, which does not respond to normal feedback mechanisms. Immunocytochemical staining for TGF-β has been performed upon six patients who had received pre-operative radiotherapy and three patients who had surgery alone for large bowel tumours. Transforming growth factor beta was found in relation to the pathological changes of late radiation damage in the non-tumour-bearing tissues of four out of six previously irradiated patients, but in none of the non-irradiated patients. This paper proposes that TGF-β activity may modulate late post-radiation changes.

Connective tissue may be severely injured by doses of radiotherapy that are tolerated by other tissues, and Ellis (1969) viewed connective tissue as that tissue upon which the limits of late radiation tolerance mainly rest. The active cells in connective tissue are fibroblasts. In rectal biopsy specimens, Wiernik and Perrins (1975) found comparable injury, in terms of cellular depletion, of fibroblasts and epithelial cells in patients having radiotherapy. The subsequent proliferation of fibroblasts and overproduction of connective tissue, which does not respond to the normal feedback inhibition that occurs in normal wound healing, has yet to be explained. Clinically this may be seen as the woody induration in the neck or fibrosis in the lung, pelvis or axilla after radiotherapy and seems particularly severe when following surgery.

Transforming growth factor beta (TGF-β) has been shown to have numerous regulatory actions upon most normal and some neoplastic cells. It stimulates stromal growth in a variety of situations and there is evidence that it is the promotor of a cascade of events which result in the formation of connective tissue (Roberts et al, 1985).

A further late effect of irradiation is vascular changes which can result in alterations in those tissues dependent on damaged vessels for their blood supply. Hypoxia, with or without stem-cell depletion, is thought to be causative in the pathogenesis of post-radiation atrophy. These effects of irradiation upon blood vessels, following an initial depletion in cell numbers, include proliferation and hypertrophy of endothelial cells and varying degrees of fibrosis and vessel occlusion. Therefore, the predominant visible lesion thought to result in late radiation atrophy is also a proliferation, in this case of endothelial cells. The effects of TGF-β upon endothelial cells vary depending on whether the cells form part of an intact tissue (Roberts et al, 1986), but *in vivo* endothelial cell proliferation can occur.

This paper proposes the hypothesis that TGF-β is produced and/or activated as a result of radiotherapy and that it acts as a mediator of post-radiation fibrosis and vascular damage.

Patients, materials and methods

Tissue samples

Six patients were identified who had received external beam radiotherapy to the pelvis prior to bowel resection for adenocarcinoma. Only patients with non-tumour-bearing large-bowel tissues within the radiotherapy fields were considered. The times between radiation and surgery are shown in Table I. All six patients received 50 Gy in 25 fractions over 5 weeks.

Negative controls

Three patients who had surgery for similar tumours but without pre-operative irradiation were used as negative controls.

Positive control

Transforming growth factor beta is known to be important in embryogenesis and has previously been described in non-human embryo limbs and cartilage. Human tissue from an abortus of approximately 15 weeks' gestation was obtained. The liver and lower limb were stained for TGF-β.

Assay

Rabbit polyclonal antibodies to TGF-β, raised against a synthesized protein consisting of the n-terminal 30 amino-acids of TGF-β-1 (Ellingsworth et al, 1986), were donated by the Laboratory of Chemoprevention,

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Table I. Positive staining for TGF-β in relation to pathological lesions. (Columns 1–4 refer to non-tumour-bearing tissue)

Radiotherapy –surgery interval	Vessel walls*	White cells in clotted vessels	White cells in stroma	Deformed epithelium	Tumour
7 weeks	–	–	–	0	+
8 weeks	–	–	–	0	–
9 weeks	+	+	+	+	+
10 weeks	–	–	+	–	+
27 weeks	+	+	+	+	+
40 weeks	+	–	+	+	+
Non-irradiated					
Patient 1	0	0	–	0	+
Patient 2	0	0	–	0	+
Patient 3	0	0	–	0	+

Key: + = lesion present TGF-β staining positive; – = lesion present TGF-β staining negative; 0 = lesion not found.
*Normal morphology in the non-irradiated patients.

NCI, Bethesda, Maryland. The antibody is thought to detect mainly intracellular TGF-β.

Tissues were fixed in neutral buffered formalin, processed through alcohol and xylene and embedded in paraffin wax.

A labelled avidin immunoperoxidase system was used. The mounted tissues were dewaxed in xylene and rinsed in alcohol. Endogenous peroxidase was blocked with 0.5% hydrogen peroxide in methanol. The sections were then rinsed in 0.1 M sodium acetate buffer pH 5.5, treated with hyaluronidase 1 mg/ml in 0.1 M sodium acetate pH 5.5 buffer and incubated for 30 min at 37°C. After rinsing in phosphate buffered saline (PBS) pH 7.6, diluted antibody (100 μl) was applied to the sections which were covered and incubated in a moist chamber at 4°C overnight. They were then washed thoroughly in PBS (3 × 3 minutes). Biotinylated swine anti-rabbit IgG was applied and the sections incubated for 30 min. The sections were washed in PBS and incubated in labelled avidin for a further 30 min. Following further washing in PBS peroxidase enzyme was revealed by incubating in diaminobenzidine for 10 min. After washing in tap water for 5 min the slides were counterstained with haematoxylin, dehydrated and mounted in DPX. Test dilutions upon the positive control suggested that an antibody dilution of 1:60 provided optimum staining and this was used for all the experimental runs.

A positive control and also a negative control, whereby the above procedure was followed but without adding the immune serum, were included in all test runs.

Results

The positive control showed intense staining in the lower limb predominantly in the basal layer of the epidermis and in osteoblasts within the developing tibia. Haemopoetic cells within the liver also demonstrated positive staining for TGF-β. These results correspond to the patterns previously reported in fetal bovine tissues (Ellingsworth et al, 1986).

Four of the patients previously treated with radiotherapy demonstrated positive staining for TGF-β in non-tumour tissues, one patient demonstrated no staining for TGF-β in any tissue and the final patient had TGF-β present only in the tumour.

The principal histological lesions in the irradiated, non-tumour-bearing, tissues were hypertrophy and proliferation of endothelium, clotted blood vessels, deposition of fibrin in the stroma, an inflammatory cell infiltrate into the stroma and atrophy and destruction of the normal epithelium. Of these features, positive staining for TGF-β was seen in relation to the deformed crypts and epithelium, thickened vessel walls, in macrophages and lymphocytes within clotted blood vessels and in macrophages within the normal tissue stroma (Fig. 1). The distribution of TGF-β was not uniform throughout any of the sections examined, particularly in the case of the inflammatory cell infiltrate within non-tumour stroma. For each patient the relationship of positive staining for the presence of TGF-β with these pathological lesions is shown in Table I.

In the non-irradiated patients these pathological lesions were absent and TGF-β was not found in any non-tumour-bearing tissue.

The tumours demonstrated positive staining for TGF-β in five out of six irradiated and three out of three non-irradiated patients.

Discussion

Transforming growth factor beta is a multifunctional peptide that can either stimulate or inhibit proliferation, differentiation and cellular biochemistry, acting by both autocrine and paracrine mechanisms. Thus TGF-β is a principal factor in the regulation of both cell growth and function and all cells have specific receptors for this peptide (Sporn et al, 1986). Transforming growth factor beta stimulates stromal growth in a variety of situations such as wound healing, and in tumours where TGF-β is continuously released by tumour cells (Derynck et al, 1987). There is evidence that TGF-β is the promotor of a cascade of events which result in the formation of connective tissue: when TGF-β is injected into newborn mice it is, of itself, sufficient stimulus to effect the formation of fibrous tissue (Roberts et al, 1985).

The effects of TGF-β upon tissues compared with the late pathological changes following radiotherapy are shown in Table II. The actions of TGF-β alone could account for the pathological features observed. However, other growth factors, including platelet derived growth factor, epidermal growth factor, fibroblast growth factor and transforming growth factor-alpha, occur in tissues and an interaction between TGF-β and these will determine the overall effects seen. Nevertheless, the range of actions that TGF-β has upon connective tissues, endothelium and epithelium suggest that it may have a pivotal role in determining the overall outcome in this context.

It is implicit in this hypothesis that late radiation

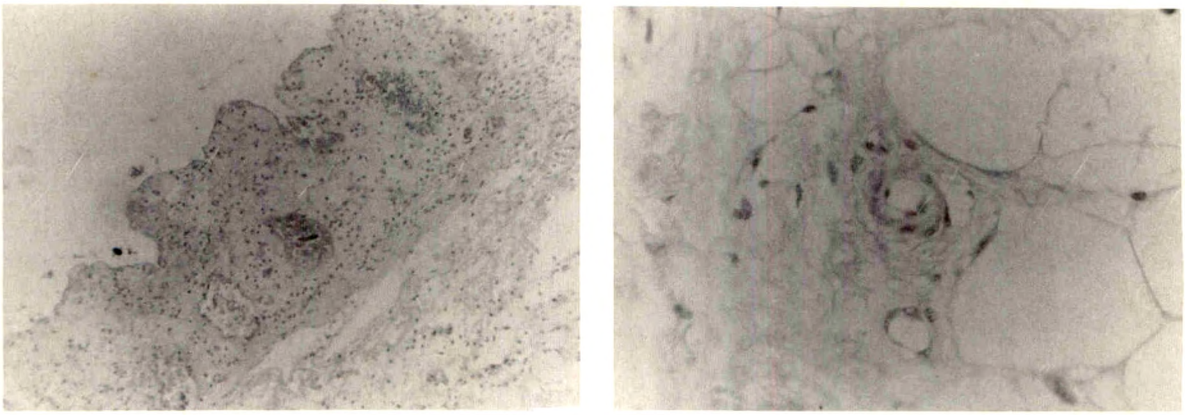
(a) (b)

Figure 1. Immunocytochemical staining of paraffin sections of non-tumour-bearing irradiated human colon with polyclonal antibody to TGF-β. Antibody localization is indicated by dark staining. (a) Deformed crypts and atrophied epithelium. Positive inflammatory cells within the stroma are also seen (× 10). (b) Staining within a vessel wall and macrophages in the non-tumour stroma (× 20).

damage is not as a result of biochemical events unique to irradiation. Similar morphological features are shared by late radiation damage, some connective tissue disorders, wound healing and tumour stroma, and these may be regulated in part by the same factors, although the presence or absence and proportions of individual factors will vary. The particular "mix" of growth factors produced in response to radiation induced tissue damage (possibly a relative lack of a TGF-β antagonist such as platelet derived growth factor) may explain the lack of normal feedback inhibition such as is seen during wound healing. It is suggested here that late radiation damage is not directly related to an immediate effect of the killing of any individual cell type but that it is a function of abnormal tissue repair.

Positive staining for TGF-β appeared from 2 months after irradiation. Post-radiation changes are time and dose dependent and a relationship between biological factors which may mediate such changes and time after radiotherapy may be expected, although there is no previous data which could be used to predict this except by inference from the clinical evolution of post-radiation damage. The differences in the intervals between radiotherapy and surgery of the patients in this study may have contributed to the inter-patient variability seen.

Human alveolar macrophages (Assoian et al, 1987) and lymphocytes (Roberts et al, 1986) have previously been shown to secrete TGF-β. An inflammatory cell infiltration of the tissues occurs following irradiation and a possible source of TGF-β in irradiated tissues is from these cells. This is supported by the positive staining of macrophages and lymphocytes described in this study.

As TGF-β was not present in similar tissues where the patient had the same tumour type and operative procedure but no radiation, the presence of TGF-β as an effect of surgery or field effect in patients who develop bowel malignancy is unlikely.

Table II. Effects of TGF-β compared with the pathological changes of late radiation damage

Effects of TGF-β	Late effects of radiotherapy
Chemotactic for fibroblasts (Postlewaite et al, 1987) Activates fibroblasts to synthesis connective tissue proteins (Sporn et al, 1986)	Tissue fibrosis
Endothelial cell hypertrophy and proliferation (Roberts et al, 1986)	Endarteritis obliterans
Epithelial cell inhibition (Sporn et al, 1986)	Atrophy

Conclusion

These initial experiments upon previously irradiated human tissue have shown that radiation damage and TGF-β co-exist and so have provided support for the working hypothesis that TGF-β is implicated in the development of the post-irradiation effects of fibrosis and hypoxia. Further experiments need to be undertaken to test for a causal relationship, and to determine the overall significance of the growth factor in the repair of radiation damage at a tissue level.

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An instance of clinical radiation morbidity and cellular radiosensitivity, not associated with ataxia-telangiectasia

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Abstract. A 14-year-old boy received standard induction chemotherapy for acute lymphoblastic leukaemia followed by standard dose cranial radiation prophylaxis (18 Gy). Severe chemosensitivity and acute radiation reactions occurred and he died at 8 months from late radiation damage. *In vitro* radiobiological studies of the boy's fibroblasts in culture demonstrated an enhanced radiosensitivity indistinguishable from ataxia-telangiectasia (A-T) cells. However, unlike A-T cells, DNA synthesis following irradiation was inhibited in a normal manner. This patient represents yet another example of extreme radiosensitivity, and the possibility of clinical prediction in the future is discussed.

Ten years ago, a 44-month-old child with early Hodgkin's disease presented at St Bartholomew's Hospital Radiotherapy Department, received standard radiotherapy and suffered very severe acute radiation sequelae, which proved fatal (Pritchard et al, 1984). The diagnosis of ataxia-telangiectasia (A-T) was confirmed (post-radiation) in this patient by radiation survival studies of cultured skin fibroblasts. A-T is a condition well known to be associated with a defect in the repair of radiation-induced cellular damage (Taylor et al, 1975; Paterson & Smith, 1979; Cox et al, 1978, 1981; Cox, 1982).

We now describe a child who presented to this Department a decade later (1500 child radiation treatments later), who also died from severe radiation morbidity. Radiation survival studies of cultured skin fibroblasts demonstrate a different pattern of enhanced radiosensitivity quite unrelated to A-T.

Case report

This Turkish-Cypriot boy presented at 14 years old with a short history of weight loss, anorexia, lethargy and pallor. He had previously been well with normal developmental progress. The child was the youngest of four siblings, the other three all being healthy young adults. Both parents were alive and well and there was no family history of disease.

Physical examination revealed a pale, thin but otherwise healthy looking boy with multisite lymphadenopathy and a slightly enlarged liver and spleen. Blood count and marrow examination gave a diagnosis of T cell acute lymphoblastic leukaemia (peripheral white blood count 51×10^9/l, 76% blasts, platelets 46×10^9/l; slightly widened mediastinum on chest radiograph). Chemotherapy was commenced according to the MRC-UKALL X protocol (vincristine 2 mg weekly, daunorubicin 60 mg on Days 1 and 2 (intravenous), l-asparaginase 8000 u alternate days (intramuscular), prednisolone 50 mg/day). Pyrexia immediately followed the first chemotherapy injection and he was treated as septicaemic with intravenous antibiotics. However, blood cultures were negative and the fever settled rapidly. By Day 3 the white blood count had fallen to 0.6 and thereafter remained below 0.5 until the 27th day following the start of the chemotherapy. During this time recurrent fevers necessitated several different intravenous antibiotic regimens and severe oral moniliasis occurred. Hypertension, cardiac gallop rhythm and pericardial rub occurred, parri passu with an episode of fluid and electrolyte disturbance (involving hypokalaemia, hypophosphataemia and hypocalcaemia). During this time, the boy lost 15% of his body weight.

The white blood count did not recover to a value above 2×10^9/l until the 45th day and the platelet count remained below 100×10^9 during this time, despite witholding further chemotherapy. All these sequelae of chemotherapy were disproportionately severe.

A bone marrow examination on the 46th day showed remission but the child was not considered fit for the standard chemotherapy consolidation and proceeded to cranial radiation prophylaxis. The cranial meninges received a mid-plane dose of 1800 cGy in 10 fractions over 12 days through parallel opposed lateral 6 MV X-ray portals. The child remained leucopenic and markedly thrombocytopenic during radiotherapy. Five days following the end of radiotherapy, the child represented with marked scalp erythema (Fig. 1) and a moist desquamative reaction behind both ears (where the build-up phenomenon places full dose on the skin surface). Fourteen days later the skin reaction was settling.

Thirty-three days following radiotherapy, the child presented with tiredness and lethargy. This was attributed to a very marked "somnolence syndrome" and lasted 3 weeks before slowly improving.

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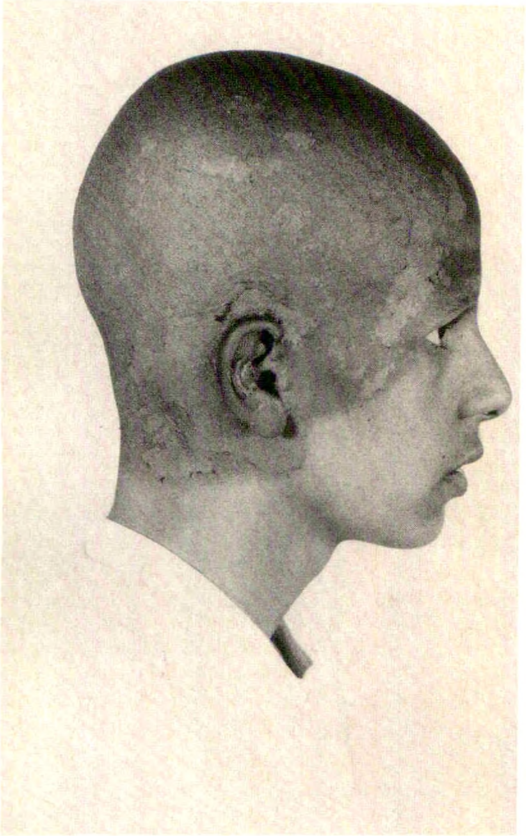

Figure 1. Lateral view of scalp erythema and skin desquamation immediately after radiotherapy.

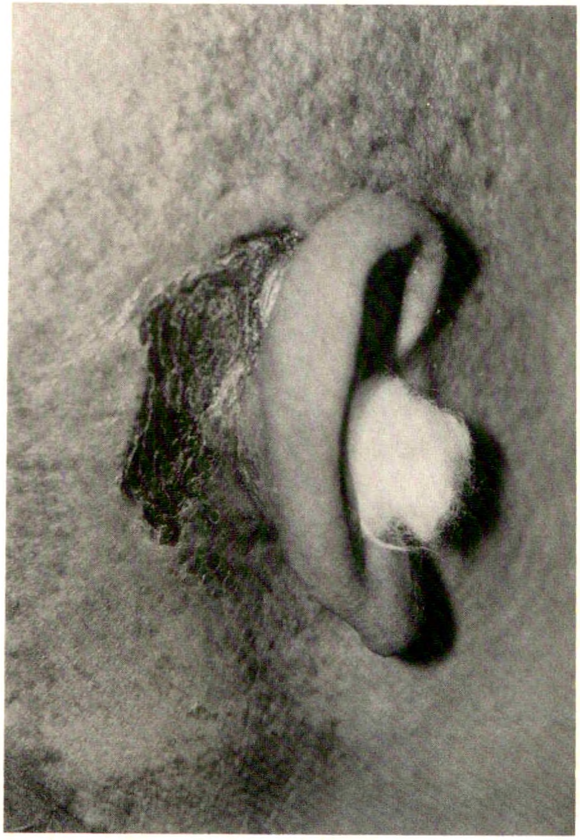

Figure 2. View of mastoid radiation ulcer 4 months after radiotherapy.

Two months after the end of radiotherapy, bilateral aural discharge occurred and ENT consultation suggested osteitis of the tympanic plate.

Maintenance chemotherapy was delivered (6 mercaptopurine daily and weekly methotrexate).

One hundred and fifteen days after the end of radiotherapy, the child presented with severe pain in the right ear. On examination there was swelling and extreme tenderness over the right mastoid. This area then sloughed to leave a necrotic ulcer over the right mastoid (Fig. 2). At about this time the child became withdrawn and progressively apathetic, sleepy and anorexic.

By 7 months following radiotherapy the child was cachectic, became confused and disorientated and unable to feed himself. An EEG showed diffuse slow wave activity consistent with radiation-induced encephalopathy. Computed tomographic brain scan showed mild generalized atrophic changes with no focal lesions. One month later flaccid tetraparesis occurred and the child became unresponsive and cyanosed owing to poor respiratory effort.

He died 8 months following radiotherapy.

Radiobiology

A fibroblast culture (designated 180BR) was established from a forearm skin biopsy (Cole & Arlett, 1984). The sensitivity to ^{60}Co γ irradiation was tested in standard protocols using either cells in cycle (Arlett & Harcourt, 1980) or cells in G_o (out of cycle). Cells were maintained in a medium containing 0.5% fetal calf serum (Arlett & Priestley, 1983). In this series of experiments the reference control cell strains were either from normal individuals (1BR.3 and 154BR) or from a radiosensitive A-T patient (AT3BR) (Taylor et al, 1975). The results which have been incorporated into our cumulative data base for all normals and all A-T cell strains (Arlett et al, 1988) are summarized in Fig. 3.

The results show that 180BR fibroblasts have a radiation sensitivity indistinguishable from A-T and that they are clearly more sensitive than normal fibroblasts. Attempts were also made to determine the radiosensitivity of the patient's T-lymphocytes (cf. Henderson et al, 1985) but viable cells were so few in number that no meaningful results were obtained.

It is characteristic of A-T cells that DNA synthesis is

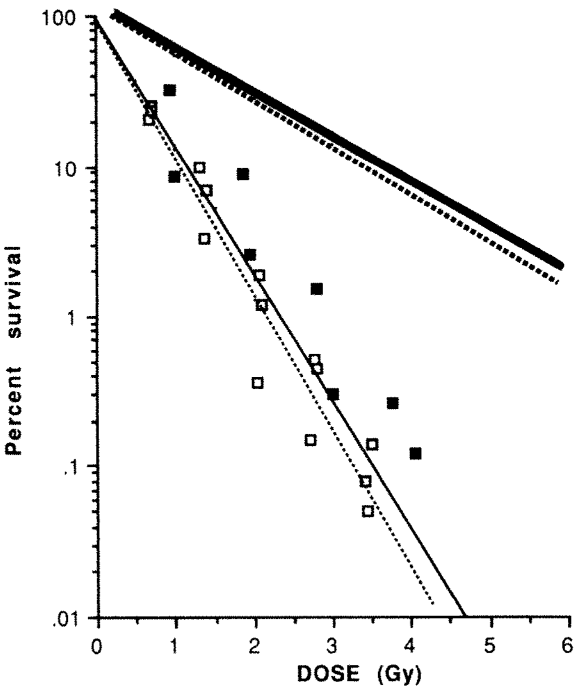

Figure 3. Gamma radiation sensitivity in cultured fibroblasts. Data from five experiments with the patients fibroblasts (180BR) are shown, two experiments with cycling cells (■) and three experiments with non-cycling cells (□). Lines are drawn from our accumulated data base (Arlett et al, 1988; Cole et al, 1988) for normals (thick lines) and A-Ts (thin lines) for both cycling (continuous lines) and non-cycling (broken lines). The individual results with reference normal (1BR.3 and 154BR) and A-T (AT3BR) cells are not displayed but are indistinguishable from the relevant data bases.

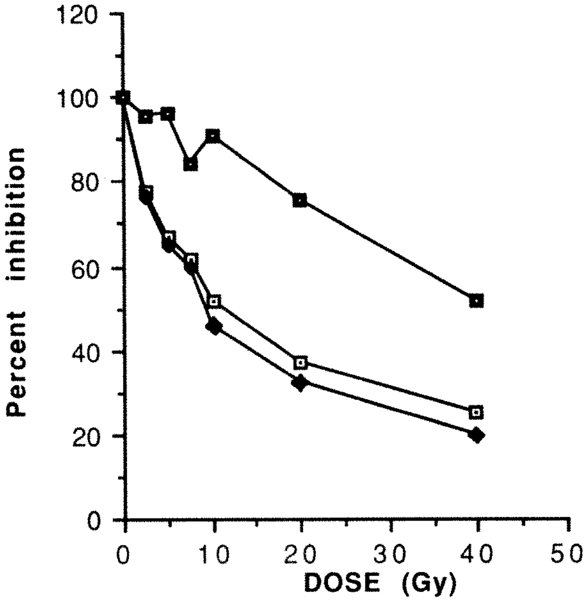

Figure 4. Sensitivity of inhibition of DNA synthesis by γ irradiation in cultured fibroblasts. A representative experiment with the patients' fibroblasts 180BR (◆), a normal control 1BR.3 (▣) and a reference A-T AT4B1 (■) is shown.

not inhibited after exposure to ionizing radiation to the extent that it is in normal cells (de Wit et al, 1981). Two experiments were carried out with 180BR cells according to the protocol of Lehmann et al (1986) and showed them to behave like normal cells in this respect and not like cells (AT4B1) from a patient with A-T (Fig. 4).

The results from these two classes of experiment show that while cells from the patient were radiosensitive they may be distinguished from A-T cells with respect to DNA synthesis following irradiation.

Discussion

The autosomal recessive condition ataxia-telangiectasia is associated with an increased risk of cancer and cells from A-T patients have shown *in vitro* sensitivity to γ radiation (Taylor et al, 1975). There is still uncertainty concerning the frequency of individuals hypersensitive to ionizing radiation among the general population (cf. Chadwick & Bridges, 1989) but the extreme sensitivity shown by A-T patients and by the present patient are rarely encountered. Other reports in the literature, however, have enough common features to be worth comparing. These fall into two groups: those where there is some clinical evidence of A-T and those where no such evidence is available. Amongst the first is the report of Fiorilli et al (1985) who described two patients from a series of seven; Case 6 had neurologic symptoms but no oculocutaneous telangiectasia, Case 7 presented with both progressive cerebellar ataxia and ocular telangiectasia. Both patients had minimal immunologic disturbance. No data for cell survival was provided but cells from both patients showed levels of bleomycin induced chromosome aberrations intermediate between those from normal and A-T cells. Normal levels of inhibition of post-irradiation DNA synthesis were recorded. Taylor et al (1987) reported three further instances of variant forms of A-T. Cultured fibroblasts from Patients 1 and 2 showed levels of radiosensitivity intermediate between that of normal and classical A-T cells. Gamma irradiation-induced chromosome damage in PHA stimulated lymphocytes was also intermediate. However, the response to DNA synthesis following irradiation was identical to that of cells from other A-T patients. For the third patient, who had an unusual protracted time course, her cells showed low levels of induced chromosome damage but the fibroblast sensitivity and inhibition of DNA synthesis was indistinguishable from cells of normal individuals. The so called "Nijmegen breakage syndrome" (Taalman et al, 1983) which is clinically distinct from A-T shows intermediate levels of cell survival between A-T and normal but inhibition of DNA synthesis characteristic of A-T.

These reports suggest heterogenicity with respect to A-T which is confirmed by observations on genetic complementation groups in A-T cell strains with common levels of radiosensitivity (Jaspers & Bootsma, 1982; Murane & Painter, 1982). They also indicate that the two radiation cellular characteristics, sensitivity and inhibition of DNA synthesis may be separated as was confirmed in an experiment where radiation sensitivity but not inhibition of DNA synthesis was corrected by transfection of normal DNA into an SV40 transformed A-T cell line (Lehmann et al, 1986).

Radiosensitivity in apparently normal individuals, albeit presenting with unusual radiation responses has also been reported. Woods et al (1988) described a female with Hodgkin's disease who developed multiple severe complications over several years following radiotherapy at the age of 13. Her fibroblasts proved to be hypersensitive to ionizing radiation to an extent similar to 180BR. A brief report on fibroblast cultures from a series of five individuals who revealed adverse reactions to radiotherapy included one (84BR) with radiation sensitivity comparable to 180BR (Arlett et al, 1989). Interestingly, cells from the other four individuals showed defective repair of potentially lethal damage, even though their radiosensitivity was close to or within the normal range.

The sensitivity of 180BR cells to cytotoxic chemicals has yet to be determined but the severe response of the patient to chemotherapy suggests that the cellular hypersensitivity may not be restricted to radiation. A-T cells have been reported to show increased sensitivity to certain radiomimetic drugs (Scudiero, 1978; Taylor et al, 1979; Edwards & Taylor, 1980; Smith & Paterson, 1980) although one study suggested that A-T patients were not more sensitive to cytotoxic chemotherapy (Toledano & Lange, 1980). Webster et al (1982) reported a female with immunodeficiency, dwarfism, immaturity of sexual development and hepatosplenomegaly with lymphomatous infiltration around the portal tracts. Her cells (46BR) were hypersensitive to radiation, although not to the extent of A-T individuals or 180BR, and they proved to be sensitive to a wide variety of DNA damaging agents (Teo et al, 1983). Subsequent work (summarized by Lehmann et al, 1988) established the existence in 46BR cells of a defect in DNA ligase 1, a central enzyme in DNA repair.

The radiosensitive patient described in this report adds to the growing list of individuals with abnormal sensitivity to radiation at the cellular level which is reflected in their response to radiotherapy. Neither the present patient's characteristics nor those of his cells are sufficiently similar to those of others to warrant the description of a radiosensitivity syndrome. Further study of individual cellular radiosensitivity is well justified in the context of radiotherapy.

The ability to predict the radiosensitivity from the response to induction chemotherapy in such children and the causative role of the underlying defect in the development of his acute lymphoblastic leukaemia are important discussion points for future patients.

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Tissue standard ratios for irregularly shaped radiotherapy fields

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Abstract. A method of calculating dose for a 6 MV X-ray beam using tissue standard ratios (TSR) is described. TSRs may be divided into a primary component and a scatter component, and the latter can then be further divided into contributions from elemental scattering volumes of 1 cm × 1 cm cross-sectional area at 1 m from the source. The magnitude of the various components have been determined by analysing measurements of square and rectangular fields, involving the fitting of the scatter data to an exponential function of radial distance from the scatter element. The coefficient and exponent of this function were found to be functions of depth, and this variation is described. A method of utilizing reconstructed scatter data that is compatible with the motion of a multileaf collimator system is presented. Results obtained by re-combining the data for various non-standard geometries are compared with further experimental work.

Tissue standard ratios (TSRs) are quantities used in conjunction with a measured reference dose to determine the dose at the isocentre within a patient undergoing X-ray therapy. As with tissue air ratios (TARs) and tissue phantom ratios (TPRs) they are, for a given X-ray energy, a function of depth, field size, and field shape. A tissue standard ratio is defined as the ratio of the dose at the isocentre for the depth, field size and field shape in question, to the dose at the isocentre for a 10 cm × 10 cm square field at 10 cm deep. Tissue standard ratios may also be defined as the product of TPRs referenced at 10 cm deep, and a relative output factor at this depth normalized to unity for a 10 cm × 10 cm square field. Saunders et al (1968) defined similar quantities, referenced at 5 cm deep, and called them modified tissue phantom ratios. As with the other similar quantities, TSRs may readily be measured and tabulated as a function of field size and depth for square and rectangular fields. Such tabulated data will, however, be of limited value for irregularly shaped fields, and particularly for complex fields generated during conformation therapy using multileaf collimators. In this paper we discuss a method of determining TSRs for irregularly shaped fields at 6 MV, which is directly compatible with the design and operation of multileaf collimators.

As with other similar quantities TSRs may be determined as the sum of a primary and a scatter component, the magnitude of the latter depending on the volume irradiated. This approach is well established (Meredith & Neary, 1944; Cunningham, 1972) and is valid for calculating the dose at points where there is charged particle equilibrium (Bjarndgard & Cunningham, 1986), but may lead to inaccuracies where this condition is not met (Mohan & Chui, 1985). Whereas, previously, the scatter component has generally been determined by a sector integration technique (Clarkson, 1941; Cunningham et al, 1972) in the present work it is determined by a rectilinear summation of the scatter from volume elements having a 1 cm × 1 cm cross-sectional area at the isocentre depth within the radiation field. This is illustrated in Fig. 1 for an 8 cm × 8 cm square field, subdivided into 64 such elements. The reason for this particular subdivision is that the scatter from each such element represents the change in scatter that results from a projected 1 cm increment in the position of one leaf of a multileaf collimator whose leaves project to a 1 cm width at the isocentre depth. One such scattering element is shown three dimensionally in Fig. 2. Strictly, the cross-sectional area of this element is 1 cm × 1 cm only in the isocentre plane as the beam is diverging geometrically, but this is of no consequence for the analysis or for the subsequent dose calculations. As narrow angle Compton scattering dominates at megavoltage energies, the magnitude of the scatter contributions from such a volume element is very largely dependent on the depth of the measurement point relative to the surface of the phantom within the scattering element. The division of the scatter into elements of this kind will then allow a depth correction to be applied for each element within the field if the radiation beam should be incident on a non-uniform surface. In principle, the primary component can be obtained by extrapolation to zero-area field size from finite field size measurements and depends only on depth. The scatter component can then be obtained by a subtraction technique. Alternatively, if the scatter components can be adequately described by an analytical function, appropriate values may be obtained by an iterative least-squares fit analysis. Such an analysis will be described later. Primary dose is defined as that which arises from radiation incident on the phantom, or patient, and can be regarded as the sum of the radiation coming from the target, and the radiation scattered from the beam defining system, flattening filter and ion chamber (BIR & HPA Working Party, 1983).

As is illustrated in Fig. 3, a particular beam dimen-

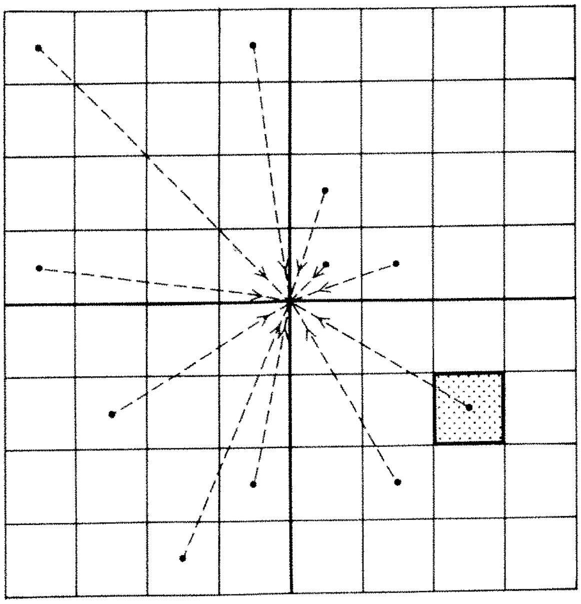

Figure 1. 8 cm by 8 cm field subdivided into 64 scattering elements of 1 cm by 1 cm cross-sectional area.

sion, *u*, is associated with different scattering geometries within the treatment head depending upon the location of the collimator jaws defining that dimension. Collimator jaws nearer to the X-ray source, as shown on the left side of the diagram, project back to a smaller dimension, *v*, at the level of the source, than do those which are further away, as shown on the right hand side, and which project to a dimension, *w*. It will be shown that variations in the scatter arising within the treatment head can be accurately modelled by assuming that it originates in the source plane which is defined as the plane containing the projection *v* and *w* in Fig. 3. It is then to be expected that a rectangular field of, say, 4 cm × 16 cm, where the smaller dimension is defined by the inner jaws, will have a different primary component to a field of the same size and shape, but where the larger dimension is defined by the inner jaws, because the two fields will project back to different shaped areas in the source plane. The scatter from the source plane will depend on what parts of that plane are uncovered by the collimator aperture, and for convenience the source plane can be divided into rectangular areas corresponding to the same 1 cm × 1 cm area at the level of the isocentre as are illustrated in Fig. 1. The ratio of the lengths of the sides of the rectangular elements is determined by the relative distances from the source to each of the two sets of collimator jaws. Again, this is compatible with incremental changes in multileaf collimator settings, and again, if an appropriate function to describe the scatter can be found, the magnitude of the scatter from each area element may be determined by an iterative least squares fit procedure.

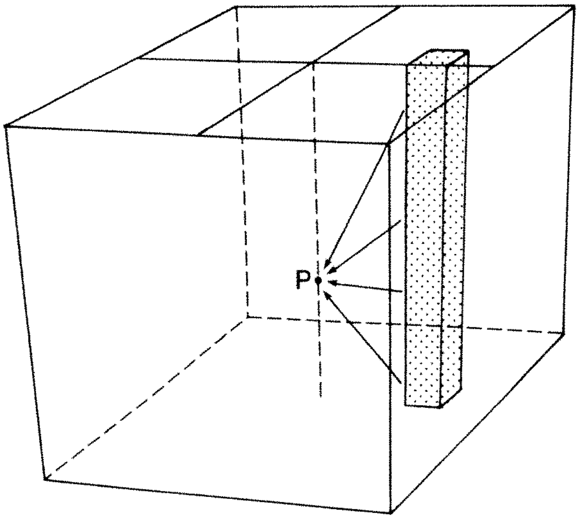

Figure 2. Scatter contribution from volume element of 1 cm by 1 cm cross sectional area to point P.

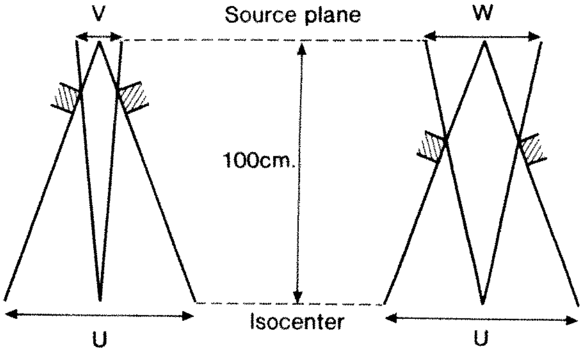

Figure 3. Diagram showing the relative areas in source plane uncovered by the same isocentric displacement of inner and outer jaws.

Experimental method

The variation of the primary component with change in field size at 6 MV was measured in air at 100 cm focus chamber distance using a 0.6 cm^3 thimble chamber with associated electrometer and a 15 mm thick Perspex build-up cap. Readings were taken for square and rectangular fields from a 4 cm × 4 cm field to a 16 cm × 16 cm field in increments of 2 cm and normalized to 1.0 for a 10 cm × 10 cm field.

Measurements for the same field sizes were carried out in a 25 cm × 25 cm × 25 cm water tank at 100 cm focus chamber distance. The surface of the water phantom was adjusted to alter the depth of the measurement position within the phantom. Again the readings were normalized to give 1.0 for a 10 cm × 10 cm field at 10 cm deep to produce TSR values.

Analysis of measured data

A first estimate of the TSR scatter components, made by the extrapolation and subtraction method, suggested

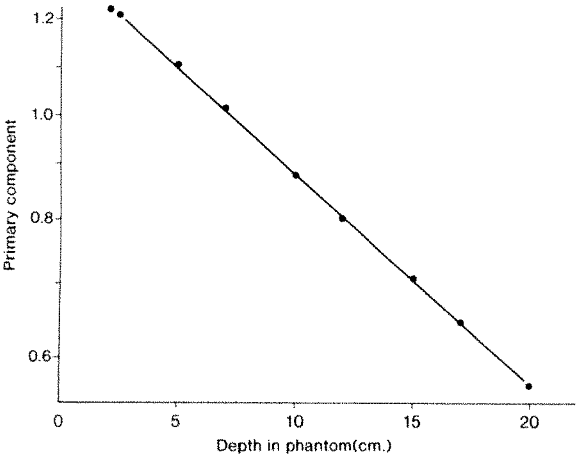

Figure 4. Variation of primary component with depth in phantom.

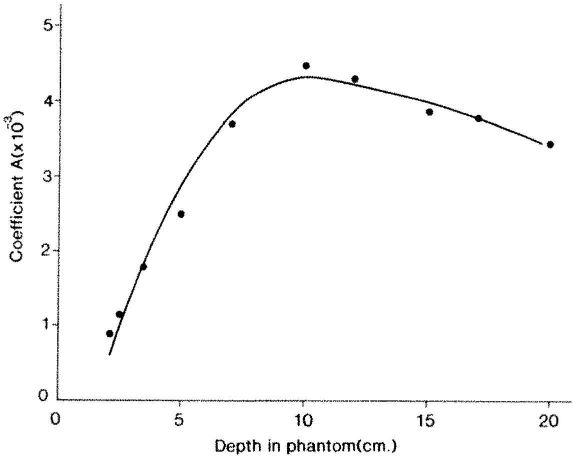

Figure 5. Variation of coefficient A with depth in phantom.

that the scatter contribution to the isocentre from a volume element, such as that illustrated in Fig. 2, can be quantitatively described by a simple exponential equation. If ΔS is the scatter contribution at the isocentre from the volume element which is at a radial distance, r, in the radiation field, then:

$$\Delta S = A(d).\exp(-b(d).r)$$

where $A(d)$ and $b(d)$ are coefficients which vary with the depth, d.

A computer program was written to generate the total scatter component for square and rectangular fields by summing the contributions from the individual volume elements as calculated using this equation. The primary component was determined by subtracting the calculated scatter component from the measured TSR for a 10 cm × 10 cm field, and hence TSRs could be generated for all field sizes for which measured data was available. A correction was made for the observed variations in the "in air" measurements, and scatter contributions from near to the field edge were weighted to allow for the geometrical penumbra. Initially the values used for the two coefficients were the best estimates from the extrapolation and subtraction procedures, and the sum of the squares of the differences between the generated and measured values of TSRs for all the field sizes was noted. The program then recycled, systematically adjusting the values of the coefficients, until the sum of the squares of the differences was minimized. The values of the two coefficients, and the corresponding value of the primary which gave the least squares fit, were recorded.

The procedure was repeated for all depths at which measured data was available. Further recycling then allowed a fine smoothing of the primary component, and of the two coefficients, as a function of depth.

A similar exponential equation to that referred to above was used to model the treatment head scatter. In this case the radial distance is that from the centre of a rectangular area element in the source plane to the centre of the source and the data are the "in air" measurements obtained with the ionization chamber in a build-up cap, but not in the water phantom. The two coefficients are now constants, and values were determined by a similar iterative least squares fit procedure to that just described. The correction referred to above for the "in air" field size variation was accomplished, in practice, by integrating an exponential function over the area in question, the coefficients being those obtained by this fitting procedure.

Results

Figure 4 shows the variation of the primary component with depth in the phantom. The circles show the values obtained from the least squares fit analysis, prior to the final smoothing stage. The line is the best exponential fit to this data, and corresponds to an effective energy of about 2.5 MeV (linear attenuation coefficient $0.044\,\mathrm{cm}^{-1}$).

Figure 5 shows the variation of the coefficient A with depth. The curve represents the values obtained after smoothing of the primary component and both scatter components, while the circles show the values obtained from the initial least squares fit analysis. There is a rapid build-up to a peak at about 10 cm deep confirming that most of the scattering is in the forward direction.

Figure 6 shows the variation of the coefficient b with depth. This is essentially the effective linear attenuation coefficient of the scattered photons. The values increase gradually with increasing contributions from multiple order scattering, pass through a peak at between 7 and 8 cm, and then decrease corresponding to a gradual hardening of the total scatter component.

The variation of the primary component with field size and shape was modelled as described earlier, with the fitting of the analytical function reproducing the asymmetry between the jaws to within ±0.5% for all field sizes measured.

Table I shows the ratio of the measured to generated TSR values for square fields and for depths from 2.1 to

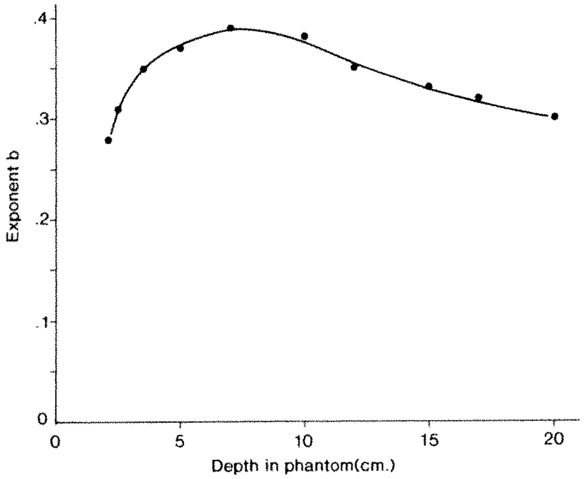

Figure 6. Variation of exponent *b* with depth in phantom.

20 cm. The smoothed data for the primary component and the two scatter component coefficients, as shown by the curves in Figs 4, 5, and 6, were used for the calculations. The correction for the "in air" variation was made using the model described earlier, and again scatter contributions from near to the edge of the field were weighted to allow for the geometric penumbra. Similar results were obtained with rectangular fields. The largest errors occur with the 4 cm × 4 cm field size, but even these are acceptably small. A good agreement is, of course, to be expected as the measured data used in the comparison are those from which the calculation parameters were determined.

It should be noted, however, that this work has been directed at calculating doses in relatively small fields where the maximum overall dimensions are 16 cm by 16 cm or less. The simple exponential function is an empirical choice which will not necessarily work as well if larger distances are involved. Discrepancies for individual scattering elements will be small, but when integrations are performed over very large areas errors greater than those indicated in Table I are to be expected. If the method is used for large field calculations then further adjustments to the data for the larger radii will be necessary.

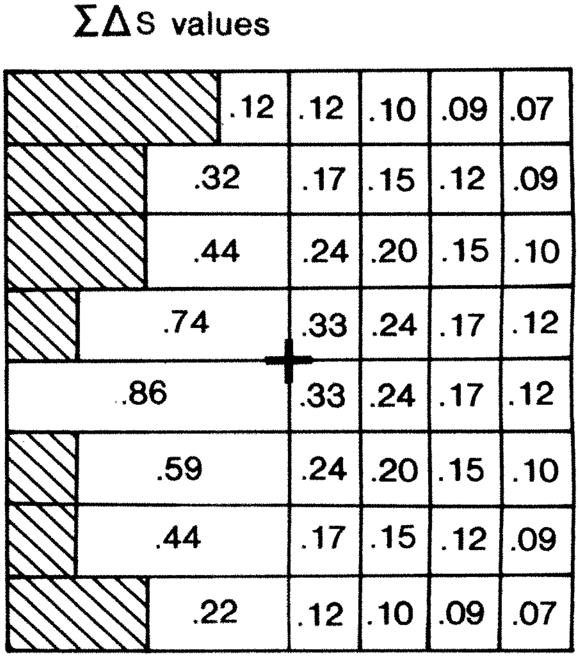

Figure 7. The use of strip integrals in the calculation of the scatter component in irregularly shaped fields.

Data handling for irregularly shaped fields

When calculating TSRs for irregularly shaped fields which are defined by multileaf collimators, it is more convenient to handle the scatter data in the form of strip integrals. The concept of a strip integral is illustrated in Fig. 7. On the right hand side the numbers represent the scatter, ΔS, from volume elements 1 cm × 1 cm in cross-section: on the left hand side they have been integrated, $\Sigma\Delta S$, over strips corresponding to the movement of the leaves of a multileaf collimator. For the purposes of this

Table I. Measured to calculated ratio of TSR values at different isocentric depths in phantom and for different square fields

	Field Size						
Depth (cm)	4 × 4	6 × 6	8 × 8	10 × 10	12 × 12	14 × 14	16 × 16
2.1	0.992	0.997	0.999	1.000	1.003	1.002	1.005
2.5	0.993	1.001	1.000	1.000	1.000	1.001	1.001
3.5	0.992	1.001	0.999	0.999	1.000	0.999	0.999
5.0	0.997	1.002	1.002	0.999	0.999	0.996	0.996
7.0	0.997	1.003	1.001	0.999	0.999	0.997	0.998
10.0	0.998	0.998	1.000	1.000	0.999	1.000	1.002
12.0	0.996	1.000	1.002	1.000	0.998	1.000	1.001
15.0	0.996	1.003	1.001	0.999	1.000	0.996	0.998
17.0	0.993	0.997	1.000	0.999	0.998	0.998	0.997
20.0	0.996	0.996	0.999	1.000	1.000	0.998	1.001

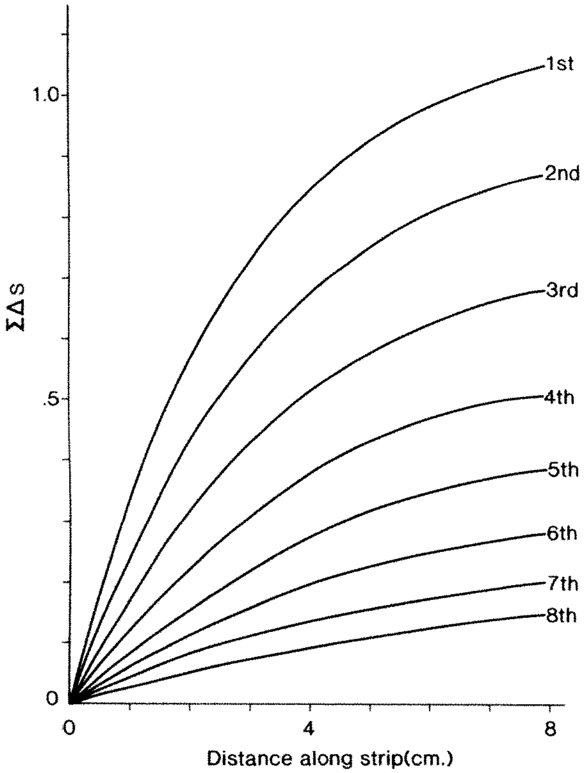

Figure 8. Summed scatter components along strips at 10 cm deep.

work it is assumed that these strips will be 1 cm wide at the depth of the isocentre. Figure 8 shows plots of strip integrals at 10 cm deep. In Figs 7 and 8 the scatter values are expressed as percentages of the total TSR for a 10 cm × 10 cm field at 10 cm deep, and it should be noted that, in general, each strip will contribute less than 1% to the total TSR. Linear interpolation from a limited set of stored values is therefore acceptable as any error in the interpolation process will have only a very small effect on the final result. Similar considerations apply for linear interpolation with depth. Small errors will be introduced by using strip integrals in cases where the entrance surface is very uneven as a single representative depth will have to be chosen for each strip. However, for most surface shapes encountered in practice these errors will be negligible.

Tests with irregularly shaped fields

As multileaf collimators have not yet been installed in any of the machines in this hospital, the method of calculation was tested for irregular shapes which were created by abutting off axis and on axis fields produced by asymmetric collimators. Four shapes chosen for comparing calculation with measurement are shown in Fig. 9, and, for example, field 1 was created as an on axis rectangular field of dimension 16 cm × 8 cm and two off axis rectangular fields each measuring 8 cm × 4 cm. For each of the four tested shapes, TSRs were measured at depths of 5, 10, 15, and 20 cm.

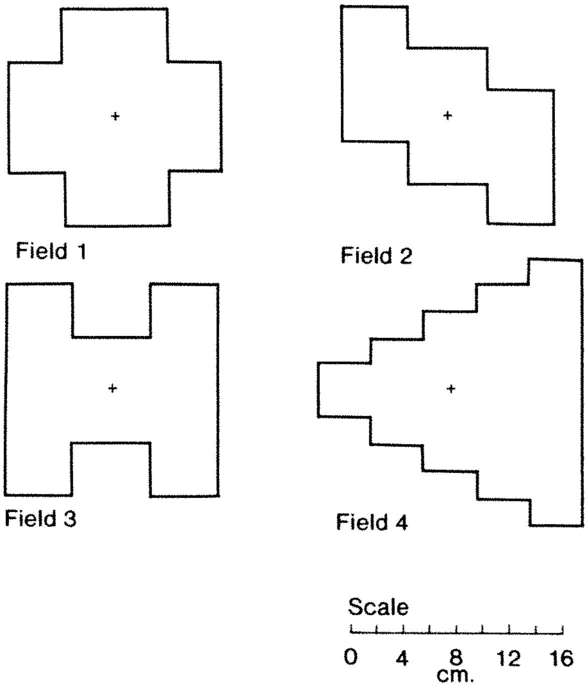

Figure 9. Irregularly shaped fields measured at different depths within the phantom.

In the calculations the scatter was determined from the strip integral data and the primary from the curve shown in Fig. 4. Where the isocentre was obscured for part of the exposure, such as when irradiating the two off axis rectangles of field 1, a correction of 0.6% was allowed for transmission through the collimator jaw. This figure was determined from "in air" transmission measurements. The ratios of the measured to calculated values for the four test fields are shown in Table II, and demonstrate that in all cases the results are highly satisfactory.

Conclusion

The dose at the isocentre is conveniently determined using tissue standard ratios. Tissue standard ratios for

Table II. Measured to calculated ratio of TSR values for irregularly shaped fields at different isocentric depths

	Field shape			
Depth (cm)	1	2	3	4
5	0.997	0.997	0.998	0.996
10	0.998	0.998	1.004	0.995
15	0.996	0.996	0.998	0.995
20	0.999	1.000	1.001	0.999

irregularly shaped fields can be calculated by combining a primary and scatter component, and the latter may be determined either by summation of strip integrals or from the summation of contributions from volume elements of 1 cm × 1 cm square cross-section. The results obtained by fitting the scatter from the volume elements to an exponential function are in very good agreement with measurements in fields where the maximum overall dimensions are 16 cm by 16 cm or less. The technique reconstructs TSR values for square, rectangular and irregularly shaped fields that are generally within ±0.5% and always within ±1% for these field sizes.

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An investigation into the performance of an automated quality assurance and dosimetry system in diagnostic radiology

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Abstract. A system has been developed to undertake automatic quality assurance and dosimetry for diagnostic radiology examinations. The accuracy and reproducibility of the measurements and calculations made by the system have been investigated in a laboratory study and compared with concurrent measurements of exposure parameters made using standard techniques. In a later set of experiments, doses measured using a RANDO phantom and thermoluminescent dosimeters were compared with those calculated by the automated system. Assessment was carried out over a wide range of exposure factors and for a number of different radiological examinations. It is deduced from the results that exposure parameters can be measured with comparable accuracy to standard techniques, and that the automated system is suitable for performing on-line dosimetry.

A number of investigations have been carried out to assess the radiation dose received by patients undergoing diagnostic radiology examinations (Harrison et al, 1983; Shrimpton et al, 1986). These and other surveys show that medical irradiation is the largest man-made contribution to the population dose in this country (Hughes et al, 1989). It is thus important to reduce such doses as far as possible, and this objective is identified in the Ionizing Radiation Regulations, 1988 (Protection of persons undergoing medical examination or treatment).

It is generally considered that quality assurance has an important role in reducing the population dose from medical irradiation (Faulkner et al, 1990). Improved quality assurance procedures have been shown to lead to a reduction in the number of repeated radiographs by reducing equipment failure rates (Hall, 1977), and this therefore reduces the radiation dosage to patients. It is also anticipated that better quality assurance procedures would minimize the variation in exposure for an individual examination.

There are several ways of performing patient dosimetry. Thermoluminescent dosimeters may be attached to the patient's skin to give a direct measurement of dose. Doses can also be estimated indirectly, by performing calculations using known exposure factors and organ dose data derived from Monte Carlo calculations. A third way of determining patient dose is to measure exposure-area-product and calculate the energy imparted.

The current methods of quality assurance and patient dosimetry are time-consuming tasks. An on-line quality assurance and dosimetry system has been developed (Faulkner et al, 1990) that will perform such procedures automatically, at the time of the exposure. This paper describes a series of laboratory experiments that have been undertaken to study the performance of this automated system. Particular emphasis has been placed on assessing the accuracy and reproducibility of the quality assurance and dosimetry measurements and calculations.

Description of instrument

A system for performing automated quality assurance and dosimetry has already been described (Faulkner et al, 1990). It consists of a Compaq 386 microcomputer, interfaced to an X-ray unit (Picker International, Vector 70 generator, control console and Picker Dynamax PX401P tube) using an analogue to digital converter (PC-30A, Amplicon Liveline Ltd). The computer collects and analyses exposure data for each radiograph. The nominal settings of tube voltage, tube current and exposure time are read from the control console by intercepting the display signals. The tube voltage waveform is determined from a potential divider in the high-tension transformer tank, and tube current waveform directly from within the generator. Both waveforms are sampled at 6 kHz, and the measurements have been calibrated by applying known signals to the points from which readings are taken. Field-size dimensions are determined from potentiometers connected to the light-beam diaphragm controls. A Diamentor ionization chamber (Radiatron Components Ltd) is attached to the tube housing, and this monitors the exposure-area-product. The Diamentor is read and reset by the computer, using the RS232 interface on the Diamentor control unit.

The operator is prompted by the computer to enter patient and examination details. The data required for performing dosimetry calculations has been stored within the computer. This consists of normalized organ dose data, comprising coefficients for a series of curves that have been fitted to previously published factors (Jones & Wall, 1985; Chapple & Faulkner, 1990), weighting factors for calculating effective dose equivalent and risk factors (International Commission on Radiological Protection, 1977). The programs for data collection and waveform analysis have been written in PASCAL, and the dosimetry calculations and data storage have been carried out using a commercial software package (SMART, Informix Software Inc). The waveform analysis consists of determining the mean peak and trough values for both tube voltage and tube current, their averages, and also the number and height of any spikes present. Information on the number and height of any spikes present is recorded to enable the investigation of any correlation of waveform spikes with tube failure and also repeat rates. The data stored in the system database includes all the measured data, patient information, the results from the waveform analysis, comparisons of actual and nominal values, and dosimetry information consisting of organ doses, effective dose equivalent, energy imparted and associated risks. In addition to this, a cumulative dose record for each patient is stored. The information is updated after each exposure is taken.

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Materials and methods

Quality assurance measurements

The accuracy and reproducibility of the quality assurance measurements were investigated by comparing them with measurements made using other techniques, taken simultaneously over a series of exposures.

The tube voltage was assessed by using a calibrated Keithley potential divider which, when attached to a calibrated storage oscilloscope, displays the tube potential waveform when an exposure is taken. Peak and trough values were obtained from this waveform, and compared with those calculated by the automated system.

The tube current was monitored by connecting a storage oscilloscope directly across the mA link in the generator from which readings are taken by the automated system. Peak and trough values were then determined from this waveform, as for the tube potential waveform above.

Exposure time was deduced from the tube potential waveform obtained using the Keithley potential divider, and compared with the result from the waveform analysis program.

Field-size dimensions were measured, with a rule, from the light-beam with the Bucky at a distance of 1 m from the focal spot of the tube. The light beam diaphragm alignment was checked before the start of the experiment by taking a radiograph, measuring the field-size from the developed film, and comparing this with the light-field.

Tube output was measured using a MDH exposure meter, with a 3 cm^3 ionization chamber. The calibration of the meter is traceable to the primary standard. The measured output was compared with the value calculated by the automated system from the exposure-area-product, which is read from the calibrated Diamentor. The output was both measured and calculated at a distance of 1 m.

Each parameter (tube voltage, tube current, exposure time, field-size and output) was investigated separately, with a series of five exposures taken for a range of nominal settings (60–120 kVp, 100–400 mA, 0.01–1 s).

Dosimetry measurements

The accuracy and repeatability of the organ dose calculations were investigated by comparison with measured organ doses for a number of radiological examinations, made using a RANDO anthropomorphic phantom, loaded with lithium fluoride thermoluminescent dosimeter chips (TLDs). Positioning for each radiographic examination was in accordance with the specifications given by Jones and Wall (1985). The exposure factors selected were representative of those used in clinical practice, and a series of exposures was taken with the automated dosimetry program running. Between 20 and 30 exposures were taken to give the TLDs a dose well above that due to background. The procedure was repeated using different sets of exposure factors, and different radiological examinations.

Additional experiments were carried out in which the beam position was shifted slightly from that specified in Jones and Wall (1985), with all other exposure conditions remaining the same.

Results and discussion

Quality assurance measurements

The method of measuring tube potential used by the automated system was compared with measurements made using a Keithley potential divider. The tube potential measurements made using the Keithley instrument are accurate to ±3 kV, when reading from the oscilloscope (Faulkner et al, 1989). There is an estimated uncertainty of ±1% in the calibration factor used by the automated system to obtain tube voltage. The mean difference and its standard deviation between the measured and calculated values was 2.69 ± 0.95, which shows good agreement between the two methods, within the anticipated uncertainty in the two readings.

An investigation was undertaken to assess the method used by the automated system to measure tube current. The uncertainty in reading from the oscilloscope is considered to be ±2%, and the uncertainty associated with the automated system's calibration factor is ±2%. Here, the mean difference and its standard deviation between measured and calculated values was 3.09 ± 3.19 mA.

A series of exposure-time measurements were performed. It was deduced from these measurements that the mean difference between the calculated value and that derived from the Keithley waveform was 1.55 ± 1.40 ms.

The accuracy of the field-size measurements made using the automated system was studied. From the

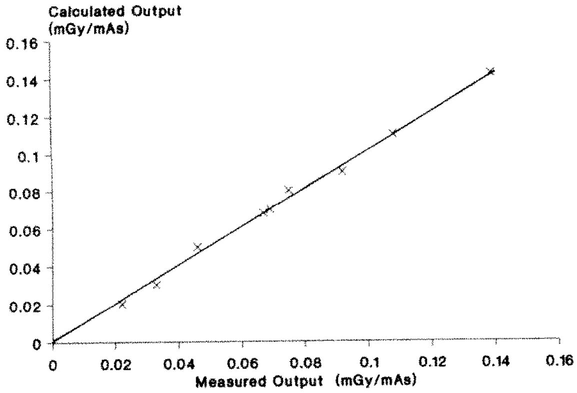

Figure 1. Output measurements. Each point is the mean of five measurements.

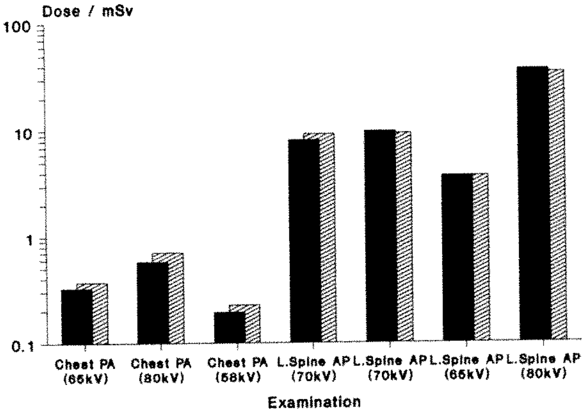

Figure 2. Measured doses (■) and calculated doses (▨) for the entrance.

calibration graphs, the uncertainty in the system measurement of each field-size dimension was estimated to be ±2%, and the manual measurements were accurate to within 0.1 cm. The mean difference between the beam dimension given by the system and that measured by hand was 0.30±0.25 cm, which is within the accuracy of the automated system for all useable field-sizes.

Figure 1 shows the X-ray tube output calculated by the system plotted against the dosimeter readings. The output is specified at a distance of 1 m in each case. The mean difference between the two is 0.002 mGy/mAs. The dosimeter had an anticipated accuracy of ±3% (Faulkner et al, 1989), and the uncertainty in the calculated output was assessed to be ±4%. The latter was deduced from the uncertainties in the Diamentor reading (PTW-Freiburg, 1988) and the field-size dimensions. The results indicate that the system is accurately calculating the tube output.

The repeatability of measurements made by the system is shown in Table I. The right-hand column gives the average standard deviation of each parameter for a series of five measurements made with identical settings. The measured values are subject to random fluctuations arising from both the automated measurement system and the X-ray tube and generator. In each case, the standard deviation on the measured parameter was comparable to the anticipated uncertainty on the measurement. It may be deduced from the data presented that the instrument is performing consistently within its anticipated uncertainty.

Table I. Repeatability of measurements

Parameter	Standard deviation
Mean kV peak	0.42 kV
Mean kV trough	1.34 kV
Mean mA peak	2.11 mA
Mean mA trough	3.17 mA
Average mA	2.06 mA
Exposure time	1.59 ms
Field-size dimension	0.15 cm
Output	2.17 e–3 mGy/mAs

Dosimetry measurements

The results of the dosimetry investigations are summarized in Figs 2–6. The histograms show the calculated and measured doses for various anatomical sites, for a number of simulated radiographic examinations. The doses shown are the average doses for a single exposure.

Entrance doses are given in Figs 2 and 3. The agreement between measured and calculated values is within 20% in all cases, and within 10% for most examinations. The estimated uncertainty in each TLD measurement is ±4%, and that derived for the calculated doses is ±7%. The latter is found from known uncertainties in the normalized organ dose data (Jones & Wall, 1985) and the calculated output. The entrance doses shown here are comparable to those presented by Shrimpton et al (1986).

The results of measurements made to assess the radiation dose received by the lungs, for various simulated

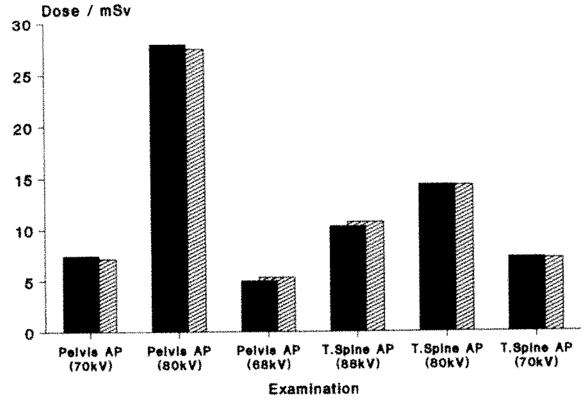

Figure 3. Measured dose (■) and calculated dose (▨) for the entrance.

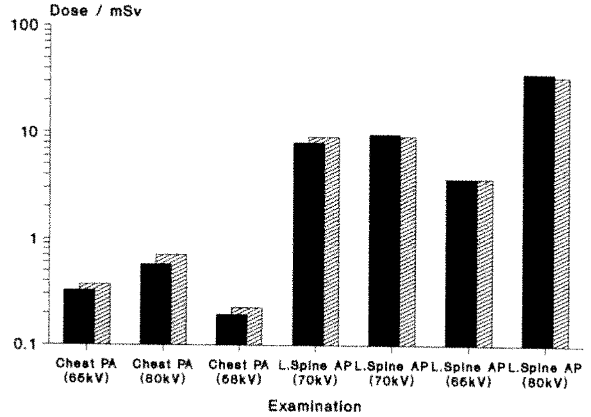

Figure 4. Measured dose (■) and calculated dose (▨) for the lungs.

radiographic exposures, are given in Fig. 4. Here, the agreement is to within 30% for the chest examinations, and to within 10% for thoracic spine examinations. Note that the latter have much higher lung doses because of the greater exposure factors commonly used for such examinations. The measured lung dose is determined from TLDs placed in several slices of the RANDO phantom, using weighting factors derived by Huda and Sandison (1984). Consequently, there is a greater uncertainty in the measured lung dose than in the more straightforward entrance dose measurements. The lung doses are also comparable to those given by Shrimpton et al (1986).

Figure 5 shows measured and calculated doses for the ovaries. Agreement between the two is to within 20% for all examinations except the chest radiographs. For chest exposures the ovaries lie outside the direct beam, and hence receive a very small dose. The TLD measurement of such a dose has a very large uncertainty associated with it, arising from subtraction of the background signal. This illustrates one important advantage of the automated system over thermoluminescent dosimetry, in that the low dose threshold for the automated system is much lower. It is determined by the dose data used, since all normalized organ dose factors smaller than 10 are set to zero, and all doses above this are measured with equal accuracy. This is an important consideration in diagnostic radiology, as organ doses from a single exposure are frequently quite low.

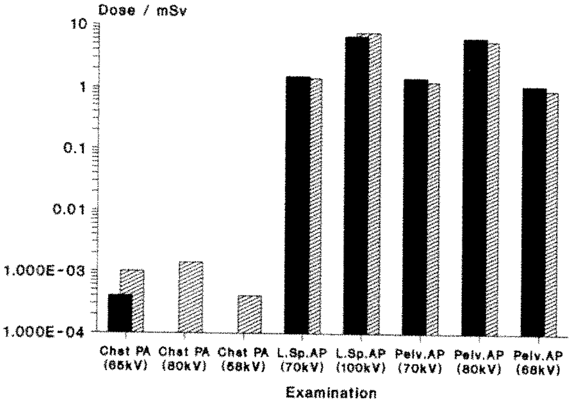

Figure 5. Measured dose (■) and calculated dose (▨) for the ovaries.

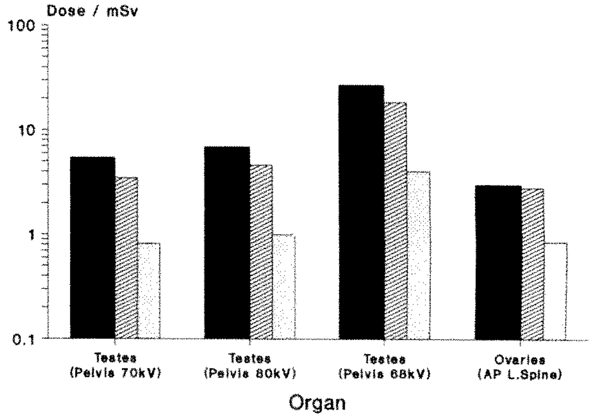

Figure 6. Effect of slight changes in beam position on 1st measured dose (■), 2nd measured dose (□) and calculated dose (▨).

The final histogram, Fig. 6, shows the effect that a change in beam position may have on organs in the peripheral area of the beam. Results are shown for a simulated pelvis examination with three different sets of exposure factors, and for a simulated lumbar spine examination. For each examination the central bar represents the dose calculated by the system. The first measured dose is that occurring when measurements are made with the organ just inside the direct beam, and the second measured dose is that which occurs when the X-ray beam is shifted so that the organ lies just outside the direct beam. The magnitude of the positional shift is of the order of 1–2 cm, and thus could feasibly occur between different exposures in clinical practice.

In each case shown, the higher measured dose is closer to the calculated dose, since the organ dose data assumes the organs are within the beam. It should be noted that the measured testes doses are all slight overestimates as the TLDs were used without any overlying tissue equivalent material.

The discrepancy between the two measured doses may approach an order of magnitude, which is a considerable increase, not only in the organ dose, but also in the effective dose equivalent to the patient. This illustrates the importance of keeping the X-ray field-size as small as possible when making a radiological examination, particularly when radiosensitive organs are near the region of diagnostic interest.

Conclusions

A series of measurements have been undertaken which indicate that the automated quality assurance and dosimetry system can measure a number of radiographic exposure parameters with accuracy comparable to standard techniques. The system will permit quality assurance to be carried out, on-line, for all radiographic exposures, and this greatly simplifies the quality assurance monitoring of the equipment.

The dosimetry results shown have several implications. Firstly, they show that the automated system gives an accurate estimate of the dose to organs within the direct beam. However, the dose to peripheral organs in any one particular patient cannot be accurately estimated using calculated organ dose data, because these doses have a large dependence on the precise position of the beam, which cannot be guaranteed. However, on a statistical basis, the doses are representative of the average organ dose for the exposure conditions. Note that the calculation of energy imparted is not affected by slight changes in beam position, and thus is an attractive and consistent method of estimating the risk to an individual patient.

Perhaps the main advantage of the automated dosimetry system is that the results for each exposure are automatically entered into a database which permits easy analysis. A vast quantity of dosimetric data can be collected in a relatively short period of time. No time has to be spent in making complicated calculations from data tables, or preparing and reading out TLDs. Furthermore, a patient's data file may be updated automatically, thus allowing accurate cumulative dose records to be kept. A further advantage over thermoluminescent dosimetry is the absence of a restrictive low dose threshold for making accurate dose measurements.

Acknowledgments

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Technical notes

A flat-top patient support for radiotherapy application computed tomographic scanning

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Computed tomographic (CT) scans for radiotherapy treatment planning must be taken with the patient lying in a position that can be reproduced exactly on the simulator and treatment unit couches. For this reason, a flat-top patient support must be placed over the dished CT cradle. The insertion of additional material in the beam may degrade the quality of the image obtained. Therefore, it is desirable that the flat-top should have a high X-ray transmission. Other desirable characteristics are that it should be:

strong—the flat-top must not be distorted by the weight of the patient;
stable;
light and easy to handle and position;
comfortable;
easy to clean and resistant to biological fluids;
low cost.

A flat-top with these features has been designed and constructed for use with a CT Pace scanner (General Electric Medical Systems).

Construction

A laminated foam core technique was chosen because of the excellent combination of strength and lightness that can be obtained.

The core of the support was cut from a block of high density polystyrene foam using a hand held hot-wire bow. The convex underside was cut out to conform exactly to the curvature of the cradle. Two layers of 0.03 kg m^{-2} glass fibre cloth and one layer of 0.6 mm obechi veneer were stuck to the upper and lower surfaces with epoxy resin. A softwood surround was glued to the edge of the core. After planing and sanding to shape the whole unit was coated with a layer of epoxy resin.

The completed support is shown in Fig. 1.

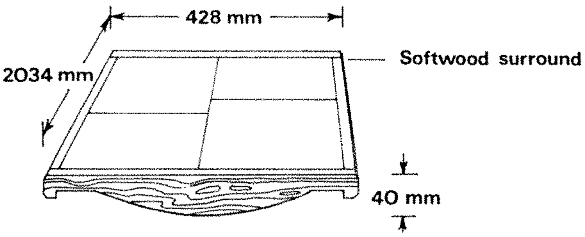


Figure 1. A flat-top patient support.

Physical properties

Some of the physical properties of the flat-top made by this department (A) and one that is commercially available from Composites Horizons Inc. (B) are listed in Table I. The latter is a 10 mm thick panel made from a foam core sandwiched between two layers of carbon-fibre-reinforced plastic. The panel has 12 small plastic feet stuck on each side which rest on the CT cradle. The edge of the panel is covered with a "U" shaped plastic strip. Carbon fibre material has been used for a number of radiographic components because of the favourable combination of high strength and stiffness with low X-ray absorption (Hufton & Russell, 1986). The cross sections of A and B are shown in Fig. 2.

Both flat-tops are narrower than a typical therapy couch (500 mm). This is undesirable but it is necessary because of the restricted space within the gantry aperture of the scanner.

Flat-top A conforms exactly to the shape of the cradle so that the weight of the patient is distributed over an area of approximately 0.6 m^2. It locates easily and reproducibly in the CT cradle. Provided that the upper edges of the cradle are at the same level then the flat top will be horizontal. By comparison, it is possible to place B asymmetrically on the cradle so that it is not horizontal. This can create obvious difficulties for treatment planning. Both supports are extremely light and easy to handle.

No deflection of the surface of either flat-top could be seen from inspection of CT scans. An assessment of the relative stiffness of A and B was made by supporting the

Table I. Physical properties of flat-tops A and B

Property	A	B
Width (m)	0.428	0.408
Length (m)	2.034	1.892
Thickness (mm)	40 (max) 18 (min)	10
Height above cradle edge (mm)	18	12
Weight (kg)	3.19	2.79
Average density (kg m^{-3})	110	363

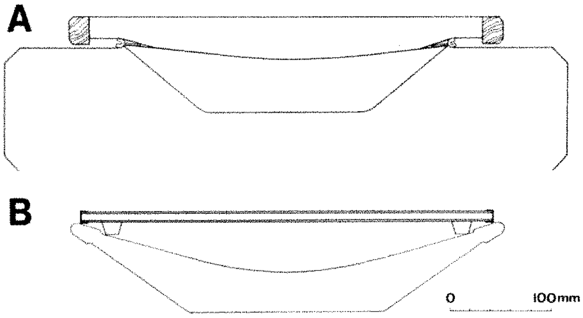


Figure 2. Cross-sections of flat-tops A and B.

flat-tops on blocks placed 1.59 m apart and applying a load at the centre. The displacement was measured with a thickness gauge (Mercer). Figure 3 shows that A has a stiffness more than three times that of B for the longitudinal axis.

X-ray transmission

The narrow beam transmission of flat-tops A and B was measured at three X-ray qualities from a Pantak Therapax 150 superficial treatment unit using a 0.6 cm^3 ionization chamber (NE 2581) and Farmer dosemeter (NE 2570).

The upper curves in Fig. 4 show the transmission at the centre of each flat-top. The lowest curve shows the transmission of the softwood surround which forms less than 10% of the width of flat-top A. The X-ray transparency of both flat-tops over the energy range 90–140 kVp is very high.

Patient Comfort

The materials used in the construction of both flat-tops have low thermal conductivities so that they feel "warm" to touch. This is helpful if the patient is to assume a relaxed and reproducible position.

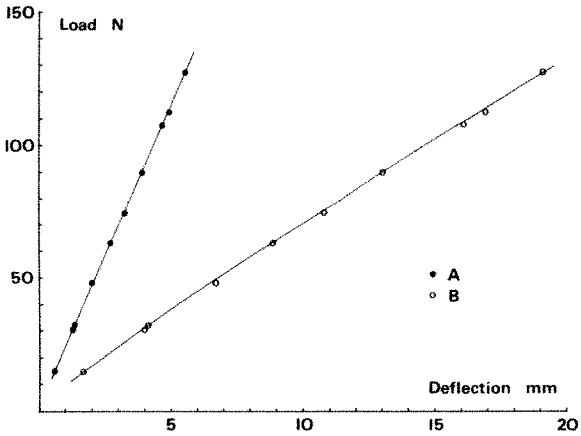
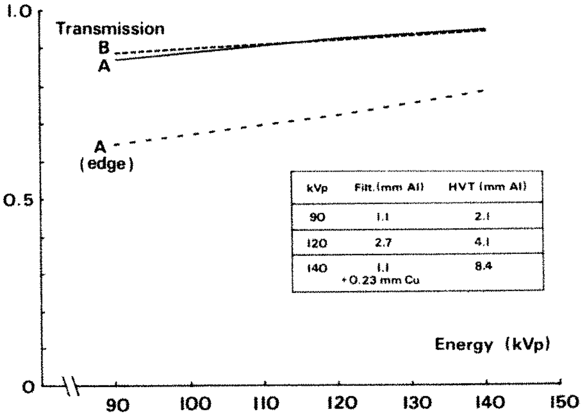


Figure 3. Load *versus* central deflection. The ends of the flat-tops were supported on blocks placed 1.59 m apart.



kVp	Filt.(mm Al)	HVT (mm Al)
90	1.1	2.1
120	2.7	4.1
140	1.1 +0.23 mm Cu	8.4

Figure 4. X-ray transmission of flat-tops A and B.

Cleaning

Both flat-tops appear to be quite impervious to common cleaning agents such as water, detergent, Hibiscrub, Savlon or hard surface disinfectant spray. Flat-top A has a smooth, closed and continuous surface that is easy to keep clean. B has a slightly textured surface and has crevices between the board and edging strip which can admit dirt and liquid.

Immobilization devices

Immobilization shells for the head and neck are locked in a baseboard which locates on each side of flat-top A to prevent rotation or lateral movement of the shell relative to the couch. The baseboard is a faithful replica, in thin plywood and soft wood, of the perspex baseboards used on the treatment units.

Cost

Materials for flat-top A were purchased for £53 while labour costs were estimated as approximately £250 (1989 prices). Flat-top B was purchased for £780 (1987). In commercial terms these costs must be considered as being very close.

Conclusion

A flat-top patient support that is light, strong and has good X-ray transmission has been constructed for radiotherapy application CT scanning. It is easy to position, stable and distributes the patient load over the whole surface of the CT cradle. In addition, it is easy to clean and resistant to commonly used cleaning agents. The flat-top uses materials that are readily available and construction techniques, such as hot-wire foam cutting, that are familiar in many medical physics departments.

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The effects of steel and titanium mandibular reconstruction plates on photon and electron beams

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The use of metal plates, designed to be screwed into the bone in reconstruction of composite mandibular defects is an accepted and widely used procedure in oral cancer therapy (Castillo et al, 1988; Sindet-Pedersen, 1988). Many of these patients must receive post-surgical radiotherapy in the course of their treatment because of possible residual microscopic disease.

The effects of radiation on tissue-metal interfaces have been studied for photon (Dutreix & Bernard, 1966; Gibbs et al, 1976; Hudson et al, 1984) and electron beams (Weatherburn et al, 1975; Khan et al, 1976; Gagnon & Cundiff, 1980; Klevenhagen et al, 1982). They have been found to result in an enhancement of the dose to the tissue in the immediate vicinity of the interface on the side facing the beam. A search through the literature has revealed limited studies on the effects of radiation beams on metal mandibular implants of the oral cavity (Castillo et al, 1988; Scher et al, 1988). These investigations were confined to stainless steel and vitallium plates irradiated with 6 MV photons.

In the last few years, titanium reconstruction plates have become available and are growing in popularity because of the increased strength relative to the thickness of the plate, greater tissue compatibility and easier adaptation to the bony fragments.

In our hospital, stainless steel mandibular implants are currently being used, and we plan to use titanium ones in the near future. Clinicians have expressed concern that necrosis of surrounding tissues is theoretically possible and could lead to complications in healing (Klotch & Prein, 1987).

The overdosage and underdosage zone at the tissue-plate interface needs to be investigated. We have therefore determined the effects of photon and electron radiations on tissues adjacent to titanium and steel plates.

Experimental methods and materials

Measurements were performed on a Philips Cobalt-60 unit, a Varian Clinac 1800 (6 MV photons) and a Philips SL 75-10 (8 MV photons and all electron measurements). The nominal electron energies were 6, 8 and 10 MeV, since these are typical radiations used in head and neck radiation therapy.

Figure 1 shows the design of the mandibular reconstruction plates (MRP) which consist of narrow bars (8 mm wide and 3 mm thick) interspaced with a series of holes. Thus any form of direct dosimetry on these plates is complicated by their design. For this reason, our investigations were done with circular plates of each material which were approximately 3 cm in diameter. The thickness of the steel and titanium plates were 2 mm (1.64 g/cm^2) and 4 mm (1.8 g/cm^2), respectively. These thicknesses do not quite correspond to those of the MRP but were used as they were the only samples available approximating the oral prosthesis.

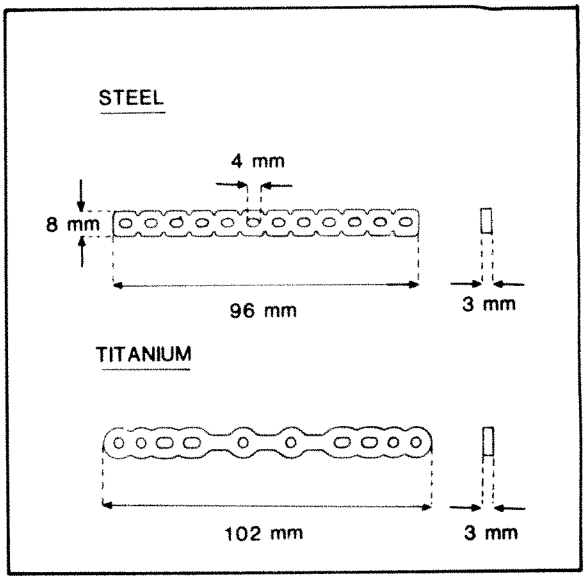

Figure 1. Construction of mandibular reconstruction plates.

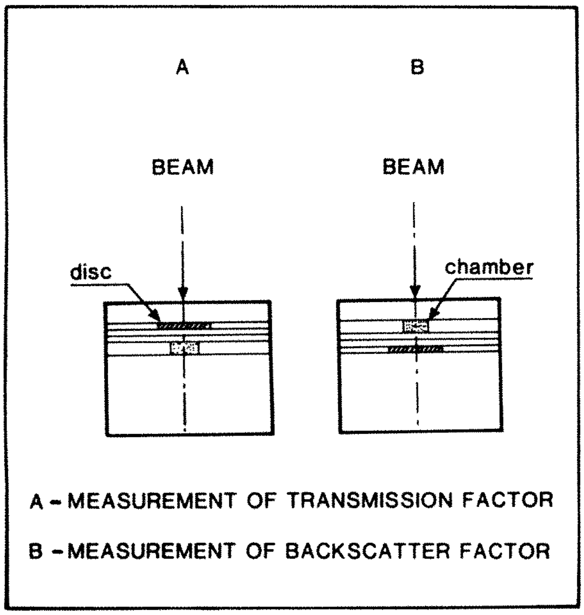
A
B
BEAM
BEAM
disc
chamber
A - MEASUREMENT OF TRANSMISSION FACTOR
B - MEASUREMENT OF BACKSCATTER FACTOR

Figure 2. Measurements with ionization chamber.

To quantify the combined backscatter and transmission effects we took the ratio of the dose at the phantom inhomogeneity interface with and without the metal present. Three separate methods of dosimetry were considered: ionization chamber, thermoluminescent dosimetry (TLD) and film. The latter was abandoned after a few preliminary measurements because of the lack of suitable manual processing facilities.

Ionization chamber

To investigate the radiation effects in the immediate vicinity of the metal interfaces we used a Capintec (PSO33) parallel plate ionization chamber, having a thin (0.5 mg/cm^2) entrance window 16 mm in diameter and connected to a Keithley 616 digital electrometer. The chamber was embedded in a polystyrene phantom with its front face flush with the phantom. Additional material could then be placed on top as shown in Fig. 2. Backscatter and transmission characteristics were measured as depicted in Figs 2a and 2b. The irradiation conditions were as shown in Table I.

Thermoluminescent dosimetry

Owing to the unavailability of thinner TLD detectors, the dosimeters chosen were Harshaw extruded LiF-100 chips (3 × 3 × 1 mm). Special polystyrene phantoms were constructed to accommodate the different sizes of metal discs used.

The TLD chips were individually calibrated and then batched into groups with a range of ±3%. For each measurement five TLD chips were placed above and below the metal discs; radiation exposures were repeated three times and the average value taken. The reproducibility between different exposures was of the order of ±7%.

Results and discussion

Variation of radiation effects with energy in the immediate vicinity of the interface

The results of measurements using the ionization chamber and TLD are shown in Tables II and III.

For both photon and electron energies studied, there was an increase in dose in the vicinity of the metal on the side nearest the radiation source (owing to backscatter) and a decrease on the other side (owing to attenuation). For the thicknesses of steel and titanium used, the attenuation has approximately the same value and shows the expected decrease with increasing photon/electron energy. The backscatter was always greater for steel than titanium, the increase of steel over titanium being about 17% for photons. The backscatter exhibits a large decrease with increasing electron energy, which was not observed with photons.

Tables II and III compare the results obtained using the flat metal discs in conjunction with TLD and ionization chamber. For the two different dosimetric systems, the results obtained with electrons are in good agreement; those with photons show a large discrepancy. The most likely explanation for this is because of the thickness of the TLDs (200 mg/cm^2). The high dose gradient shown in Figs 3 and 4 is being averaged out. This suggests that careful consideration should be paid to the method of dosimetry, otherwise serious underestimation of the dose at the interface may occur when using a "thick" detector such as a TLD chip.

From previous studies with 6 MV photons and steel, Scher et al (1988) reported a value of 20% for the backscatter, using an ionization chamber. Castillo et al (1988) quoted a value of 17% obtained from TLD

Table I. Irradiation conditions

Machine	Cobalt Philips	Varian Clinac 1800	Philips SL 75-10	
Mode	γ-Photon	X-ray	X-ray	Electrons
Energy	1.25 MeV	6 MV	8 MV	6 MeV 8 MeV 10 MeV
Source–surface distance (cm)	80	100	100	100
Field size (cm × cm)	15 × 15	15 × 15	15 × 15	12.5 × 12.5
Build up (cm)	0.5	1.5	2.0	1.0

Table II. Variation of dose with energy in the immediate vicinity of interface measurement with ionization chamber

Machine	Cobalt Philips		Varian Clinac 1800		Philips SL 75-10							
Mode	γ-photon		X-ray		X-ray		Electrons					
Energy	1.25 MeV		6 MV		8 MV		6 MeV		8 MeV		10 MeV	
Material	Steel	Titanium	Steel	Titanium	Steel	Titanium	Steel	Titanium	Steel	Titanium	Steel	Titanium
Absorption (%)	20	20	15.5	15.7	13	12.5	76	80	44	48	14	13.5
% BS	37.6	30	35.6	30	35	29	27	22	23	18	18	13

Table III. Variation of dose with energy in the immediate vicinity of interface measurement with TLD

Machine	Cobalt Philips		Varian Clinac 1800		Philips SL 75-10							
Mode	γ-Photon		X-ray		X-ray		Electrons					
Energy	1.25 MeV		6 MV		8 MV		6 MeV		8 MeV		10 MeV	
Material	Steel	Titanium	Steel	Titanium	Steel	Titanium	Steel	Titanium	Steel	Titanium	Steel	Titanium
Absorption (%)	15	16	14.9	12.3	10	10	84.2	88	47.4	52	13.6	18
% BS	19	15.2	19	15.8	19.5	15.7	28.8	19	22.8	15.6	21.4	11

measurements (3 × 3 × 1 mm chip size). Our corresponding values are 36% and 19%, respectively. The seemingly large difference between Scher's ionization chamber measurements and ours is again probably because of the fact that Scher et al used a chamber with a thicker window (0.5 mm).

For electron beams, Klevenhagen et al (1982) suggested an expression relating the magnitude of the backscatter with energy:

$$EBF = A - B \exp(-KZ)$$

where Z is the atomic number, A, B and K are constants which depend upon the electron beam energy at the metal surface. We have compared our results with this expression in Table IV. The values of A, B and K have been extrapolated for the lower energy. We are in good agreement with these authors except for titanium and 10 MeV electrons, where our value is a little lower (13% compared with 15.7%).

Effect of field size and metal thickness (photons)

Additional measurements were carried out with 8 MV photons on the Philips accelerator varying (i) field size for a given thickness of material and (ii) thickness for a given field size. We observed no variation in backscatter with field size in the range of 5–15 cm^2 (approximating to the range of field sizes used in radiation therapy of the head and neck). The average backscatter value is 34.5% for steel and 29.4% for titanium. Furthermore, for the thicknesses considered (2–20 mm), the backscatter appears to be independent of the thickness of the two materials. Thus, the values of backscatter found for 2 and 4 mm should be similar to that for 3 mm (MRP thickness).

Variation of dose with distance from metal interface

Using the ionization chamber and the flat metal discs the variation of dose with proximity for steel and titanium was investigated for Co-60 and 8 MV photons (see

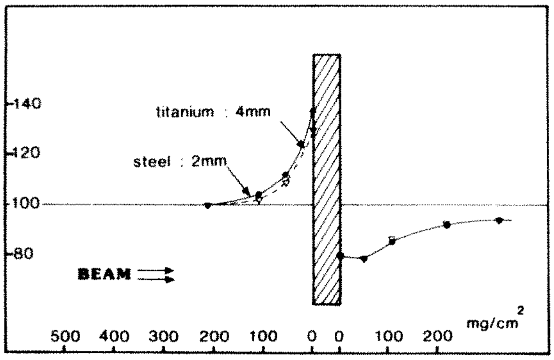

Figure 3. Variation of dose in the vicinity of the metal disc on Cobalt-60 with ionization chamber.

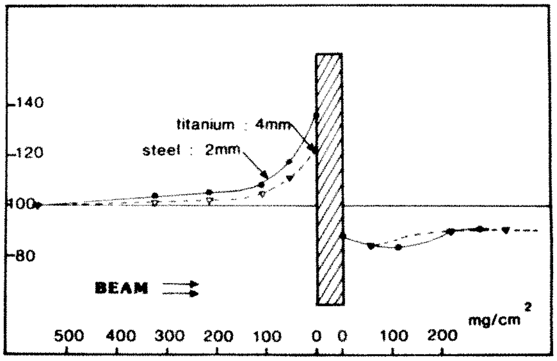

Figure 4. Variation of dose in the vicinity of the metal disc using 8 MV photons and ionization chamber.

Table IV. Magnitude of electron backscatter for steel ($Z = 25.6$) and titanium ($Z = 22$)

Nominal energy (MeV)	E_Z (MeV)	Steel		Titanium	
		Calculated value*	Our value	Calculated value*	Our value
6	3.35	27.6	27	23.0	22
8	4.50	24.3	23	20.0	18
10	6.35	19.0	18	15.7	13

*Using the expression of Klevenhagen.

Figs 3 and 4). The results indicate that the effects of backscatter are only evident very close to the interface but involve a larger thickness of tissue with higher energies (<3 mm for Co^{60} and <5 mm for 8 MV photons). Scher et al (1988) found a zone of tissue overdosage and underdosage of about 2–3 mm with steel plate and 6 MV photons. Gibbs et al (1966) report a zone of 2–4 mm for a gold crown irradiated with 4–6 MV photons, and Dutreix and Bernard (1966), 2–3 mm for copper and cobalt.

Conclusion

When treating patients with megavoltage photon/electron beams, special attention should be paid to the dose in the vicinity of the metal surface. This is particularly important when using single portal beams. For a typical dose of 50 Gy with 6 MV photons and a steel implant, there will be an increase in dose of 17.5 Gy on one side and a decrease of 8 Gy on the other. Owing to the compensating nature of the two effects, this is reduced to 7.5 Gy on both sides when two parallel opposed beams are used. By choosing titanium plates the inhomogenity can be reduced by a further 17%, thus making titanium a more suitable material for prosthesis when radiation therapy is anticipated. One note of caution: the titanium plates are three times more expensive than the steel ones.

From our experience in this hospital based on 15 cases over the last few years, we have observed only the normal reactions expected from radiation therapy. One cannot however discount the possibility of a thin layer of necrosis in the region in direct contact with the plate since this is very difficult to observe.

Finally, in assessing the magnitude of the effects,

(1) special care should be taken in choosing the dosimetry system or, as indicated by our measurements, serious under estimation of dose may occur;

(2) there may be further dose modification, since the MRP are not homogeneous as were the flat metal discs used in the investigation. The dose in the smaller shadow of a perforated MRP (Fig. 1) will be greater than that measured in the shadow of a solid 30 mm disc because of the differing distribution of scatter. The compensating nature of the two effects in opposed beam radiotherapy may not be as good as suggested.

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Case reports

Invisible pulmonary markings due to air in the pulmonary vasculature: a post-mortem study

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Pulmonary vascular markings were invisible on a post-mortem chest radiograph because of air in the pulmonary vessels in a patient who had exsanguinated. This unusual case illustrates that it is the blood in the pulmonary arteries and veins, rather than the vessels' walls, that accounts for the normal lung markings on the plain chest radiograph.

Case report

An 18-year-old woman committed suicide with a shot-gun blast to her brain. A post-mortem chest radiography was taken for forensic purposes (Fig. 1). This shows air in the heart and pulmonary trunk, bilateral hypertransradiant lungs, there being almost complete absence of lung markings. At autopsy the lungs were found to be fully expanded, but there was widespread air in the pulmonary vasculature.

Discussion

The normal anatomy of the lung as seen on the standard plain chest radiograph is a composite of contrasting shadows cast by air, bronchopulmonary tissues and blood. Conventional teaching is that so-called "pulmonary markings" are due to pulmonary vessels which in life, except when complicated by thromboembolism, are always filled with circulating blood (Sutton, 1987). The radiographic manifestations of pulmonary air embolism have been reported previously (Kizer & Goodman, 1982). However, the post-mortem radiograph in this unusual case, in which not only had the patient exsanguinated but virtually all of the pulmonary circulation was replaced by air, illustrates a point that has not previously been emphasized, namely,

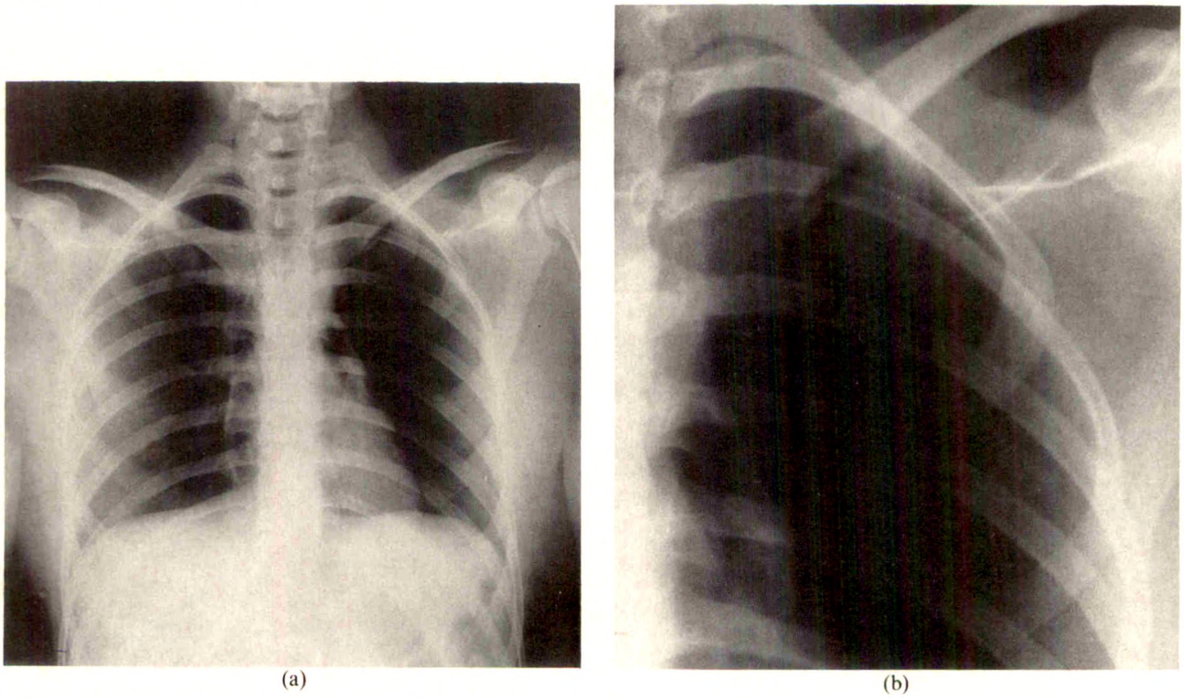
(a) (b)

Figure 1. (a) Post-mortem chest radiograph showing air in the heart and main pulmonary artery, bilateral hypertranslucent hemithoraces and absence of vessel markings. At autopsy the lungs were fully expanded. (b) Enlarged view of the left upper zone.

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it is circulating blood which we see on standard chest radiographs as "pulmonary markings" rather than the walls of the pulmonary arteries and veins.

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We would like to express our appreciation to Mr J. Ashworth, Superintendent Radiographer, Lymington Hospital, who had the presence of mind to take a chest radiograph in these circumstances.

Computed tomography demonstration of portal venous gas after hepatic artery embolization

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Hepatic portal venous gas is an entity frequently associated with a sinister outcome in infantile necrotizing enterocolitis, small bowel infarction and intra-abdominal sepsis (Sisley et al, 1987). A recent case report described its occurrence in a patient receiving monoclonal antibody therapy (Waymack et al, 1987).

We describe a case in which portal venous gas appeared secondary to therapeutic embolization of the hepatic artery, a phenomenon which, to our knowledge, has not been reported previously. The diagnosis was made by computed tomography (CT) and the gas remained in the portal system for at least 8 days.

Case report

A 22-year-old male patient was referred from another hospital following a road traffic accident 2 weeks previously. Laparotomy immediately after the accident had revealed two deep lacerations in the right lobe of liver which were controlled by suturing and drainage. Post-operatively the patient had a persistent pyrexia followed 2 weeks later by melaena and haematemesis associated with hypotension and right hypochondrial pain. An enhanced CT scan showed a central hepatic haematoma, with active bleeding into the biliary tree. Plain radiographs at this time showed no evidence of gas in the portal venous radicles. He was transferred to Hammersmith Hospital where immediate visceral angiography was undertaken, which revealed a fistula connecting branches of the right hepatic artery, right portal vein and right hepatic duct, with vigorous bleeding. Following embolization of the right hepatic artery with Gelfoam and steel coils, a post-embolization angiogram revealed a second fistula arising from the left hepatic artery, and this was also embolized.

On the night following the embolization, the patient developed fever and severe right upper quadrant pain. The following day he underwent a laparotomy, at which a tense gallbladder filled with thrombus was removed, and several perihepatic abscesses drained. Operative cholangiography showed two small intrahepatic collections and some thrombus in the biliary tree. He made good progress for 1 week, though he remained mildly pyrexial.

A CT examination revealed low attenuation of the posterior segments of the right lobe of the liver, which contained central air-attenuation areas. The gas was seen to be sited peripherally in a branching pattern, corresponding with portal venous radicles (Fig. 1).

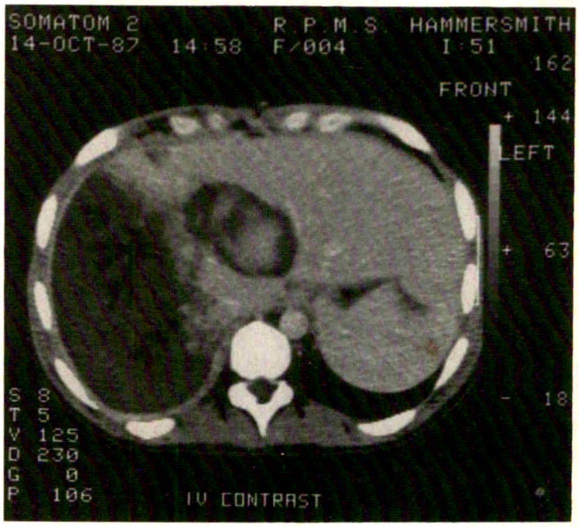

Figure 1. Computed tomographic scan through the liver showing infarction of the right lobe with gas in the portal venous branches and a central mixed attenuation lesion, consistent with a haematoma.

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The cause of these findings was thought to be infarction of the right lobe, secondary to embolization. There was no evidence of bowel ischaemia, infection or any other recognized cause of gas in the portal venous system, and it was felt very unlikely that surgery would have caused such a substantial amount of gas in the system.

A follow-up CT scan 8 days later revealed similar changes with no significant difference in appearances.

Despite being maintained on parenteral antibiotics throughout his stay in both hospitals, the patient showed signs of persisting clinical evidence of sepsis and was returned to the operating theatre. Almost the entire right liver was softened and necrotic, and resection of this tissue was undertaken which amounted to a formal right hepatectomy. Despite a stormy post-operative course complicated by subphrenic abscess, he eventually made an excellent recovery and remains well 16 months later.

Discussion

The diagnosis of portal venous gas is still usually made on plain abdominal radiography. A typical branching pattern of air is seen projected peripherally over the liver, in contradistinction to aerobilia which is more centrally located. The patient is usually very ill, often moribund, or has had a recent event which is recognized as being associated with the complication of portal venous gas (*e.g.* necrosis of the bowel). Sisley et al (1987) first reported the use of CT scanning to make the diagnosis.

The finding of gas in the liver following therapeutic embolization is not a new observation. It has been known for many years that parenchymal gas may be seen after vascular occlusion, and Allison et al (1985) showed that the phenomenon could be demonstrated by plain films, ultrasound and/or computed tomography in almost 50% of patients undergoing extensive hepatic arterial embolization. The appearance of the gas occurring under these circumstances is different and stippled distribution rather than being in a focal collection. The mechanism of this gas production is ill understood but one possibility is that it may be a result of the release of oxygen from the red cells trapped in embolized vessels (Allison, 1988). In most cases of hepatic embolization, portal flow is left deliberately unaffected and any gas produced by the procedure is confined to the liver parenchyma; it is never seen in the portal vein. In the rather unusual circumstances of the present case, however, in which segmental liver infarction is known to have occurred, we believe that portal flow through the infarcted segments was compromised. In this situation gas may have appeared in the portal vein either directly from the blood trapped in the vein (in a manner analogous to that seen in the arteries in intrauterine fetal death) or by diffusion from the surrounding (embolized) parenchyma.

Whatever the true explanation for the features described in this case, we know that the usual causes for portal vein gas did not apply, and that the phenomenon observed was almost certainly related to the presence of infarcted tissue.

The conclusion we draw from this case is that while the appearance of *parenchymal* hepatic gas following embolization is, in the absence of infection, a benign phenomenon, the appearance of *portal* gas in this situation is probably a portent of liver infarction, a diagnosis that will clearly have important implications with regard to the future management of the patient.

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Radiation therapy in the management of giant lymph node hyperplasia

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The response of giant lymph node hyperplasia (Castleman's disease) to surgery is well known and surgery is the main technique in the management of these patients. We describe a young man who presented with clinical features suggestive of a lymphoma, but who was diagnosed to have Castleman's disease after histopathology. Complete response to radiation and a disease-free follow-up of 22 months prompts us to advocate radiation as an effective alternative mode of therapy in inoperable cases.

Giant lymph node hyperplasia or Castleman's disease

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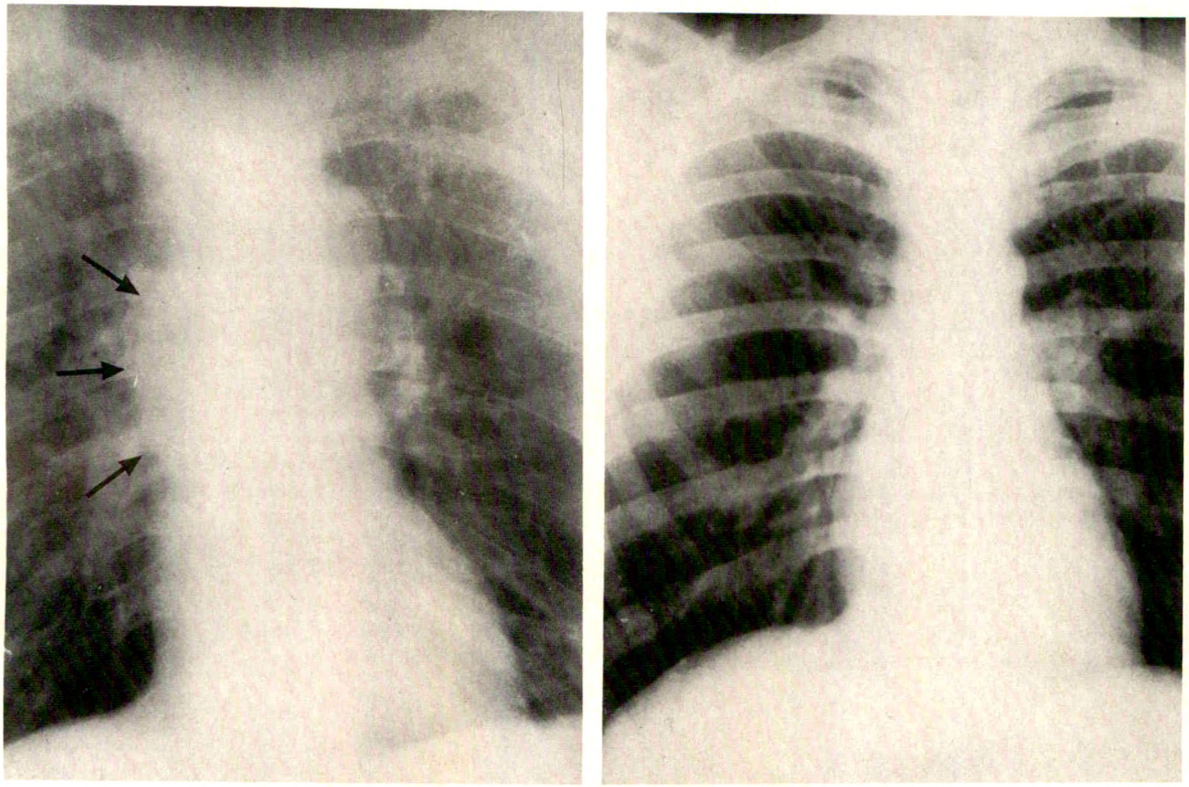

(a) (b)

Figure 1. (a) Radiograph of the chest taken prior to radiotherapy, showing widening of the mediastinum (arrows). (b) After radiotherapy, the chest radiograph was normal.

is a benign condition with enlargement of the lymph nodes, particularly common in the mediastinum. The patients are otherwise usually asymptomatic but may sometimes present with fever, anaemia, hyper-gammaglobulinaemia (Bartoli et al, 1980; Frrizera et al, 1983) and multi-centric lymph node enlargement (Gaba et al, 1978) mimicking a lymphoma. Keller described the two well known morphological forms, the hyaline vascular and plasma cell types, the former being more common (90% of the cases) while the latter is associated with systemic manifestations (Keller et al, 1972). Surgery remains the mainstay in the management of these patients (MacKay, 1969; Keller et al, 1972) but isolated reports stressing the role of radiotherapy have also been documented (Fitzpatrick & Brown, 1968; Emson, 1973). We report a young patient with the hyaline vascular type of Castleman's disease who presented with localized lymph node enlargement and systemic manifestations. The remarkable improvement with complete disappearance of lymph nodes and other systemic manifestations and disease-free interval of 22 months with radiotherapy alone, makes this case worth documenting.

Case report

A 25-year-old man presented with a gradually increasing painless mass on the right side of the neck of 3 years duration, and low grade fever for the previous 18 months. There were no other associated symptoms. Physical examination revealed multiple, matted, firm lymph nodes 2–5 cm in size in the right submandibular region. There was no involvement of any other group and the systemic examination was normal. The patient was investigated with a clinical diagnosis of lymphoma, Stage IB.

The haemogram revealed mild reduction of haemoglobin (9.5 gm/dl) with normal total and differential leucocyte counts. Serum electrophoresis showed hyper-gamma-globulinaemia with total proteins of 8.3 gm%, albumin fraction comprising 4.0 gm%, and globulin of 4.3 gm%. A radiograph of the chest showed widening of the superior mediastinum (Fig. 1). A fine needle aspiration cytology of the lymph node mass done on two occasions and a lymph node biopsy showed only reactive lymphoid tissue. A diagnosis of Castleman's disease was made on a repeat biopsy.

Histologically, the biopsy revealed replacement of the normal lymph node architecture by numerous small follicles, each with a central blood vessel showing plump endothelial cells and eosinophilic hyaline material (Fig. 2). The interfollicular component consisted of small lymphocytes admixed with few plasma cells and eosinophils. There was no increase in the mitotic activity. Thus the features were diagnostic of Castleman's disease of hyaline vascular type.

The treatment given was 20 fractions of 200 cGy, a total of 4000 cGy over 4 weeks, five fractions/week, localized external radiation was delivered by a direct single field. At the completion of the treatment there was 50% reduction in the lymph node size and complete disappearance of the lymph nodes 1 month later. As the patient became completely asymptomatic

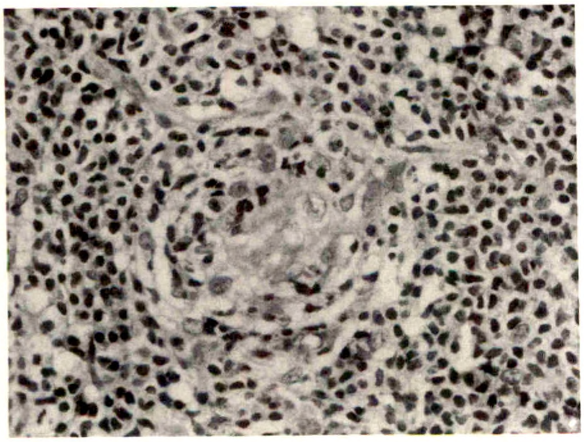

Figure 2. Photomicrograph of the lymph node showing a small "follicle" with a central blood vessel and eosinophilic hyaline material. Note the concenteric arrangement of lymphocytes around the blood vessel (H & E × 550).

and a repeat radiograph of the chest (Fig. 1b) was normal, additional radiation to mediastinum was deferred. On close follow-up, the patient has remained symptom free for 22 months.

Discussion

Two aspects merit discussion in this case. Firstly, the efficacy of radiotherapy in Castleman's disease has not been clear to date. The numerous conflicting reports on the advocated doses and the observed responses further complicate the issue. Keller et al, in their series, initially instituted radiation (1800–4300 cGy) before resorting to surgery as there was no clinical response (Keller et al, 1972). Emson (1973) and Fitzpatrick and Brown (1968) documented a decrease in the size of lymph node masses in 2 to 5 years with higher doses (3500–4500 cGy) of radiation. Nordstrom et al (1978), Weisenburger et al (1979) and Stokes et al (1985) recorded relief of local and systemic symptoms with radiation alone. In these cases 4000 cGy in 20 fractions resulted in complete disappearance of the lymph node mass with relief of clinical symptoms, suggesting a useful role for radiotherapy alone in the treatment of these cases. Experience from treating a larger number of such patients would further clarify this aspect.

Secondly, systemic manifestations like fever, anaemia and hyper-gamma-globulinaemia, as seen in this case, are rare in the hyaline vascular type of Castleman's disease (Bartoli et al, 1980; Martin et al, 1985). Two possibilities can be proposed to explain this phenomenon (Keller et al, 1972): (i) the presence of plasma cells in the biopsy may be an indication of a possible evolution of the plasma cell type from the hyaline vascular type; (ii) the two types may be variants of the same process with different patterns of host response.

In conclusion, radiotherapy can be a useful adjunct in the management of Castleman's disease, particularly in patients who are at high risk of recurrence or who are unsuitable for surgery.

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Strongyloidiasis of the colon

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Case report

A 60-year-old Iraqi woman with chronic B-lymphocytic leukaemia was admitted with pyrexia, generalized abdominal pain, cough and sputum.

Two years previously she had been admitted to hospital with right upper quadrant pain. Investigations at that stage, including ultrasound and acetanilidoiminodiacetic acid (HIDA) scan, had been negative. The pain had recurred intermittently since then.

One month before admission she had noticed a worsening of her pain and she was unable to sleep. At that time her white cell count had increased and she was commenced on a 2-week course of chemotherapy.

On examination she looked pale and unwell. Her temperature varied between 37.5°C and 40°C. There were petechiae on her back and upper arms and an erythematous rash on her trunk. There were widespread wheezes in her chest. Examination of the abdomen revealed generalized tenderness, maximal in the right upper quadrant, and mild splenomegaly.

Initial investigations showed a raised erythrocyte sedimentation rate and a leukaemic blood film. All types of immunoglobulins were reduced. An abdominal ultrasound was normal.

In view of the fever and abdominal tenderness a ^{111}Indium labelled white cell scan was performed (Fig. 1). This demonstrated marked increase of activity in the region of the ascending colon, thought to be a result of localized infection or colitis.

Following the white cell scan, a computed tomographic scan of the abdomen was carried out (Fig. 2). This showed thickening of the wall of the ascending colon and some ill-defined high attenuation areas in the surrounding fat. These findings were suggestive of a localized colitis. Stool culture and microscopy was done following the radiological investigations and parasites were seen with the typical appearances of *Strongyloides stercoralis*. The patient was commenced on thiabendazole and became apyrexial within 48 h.

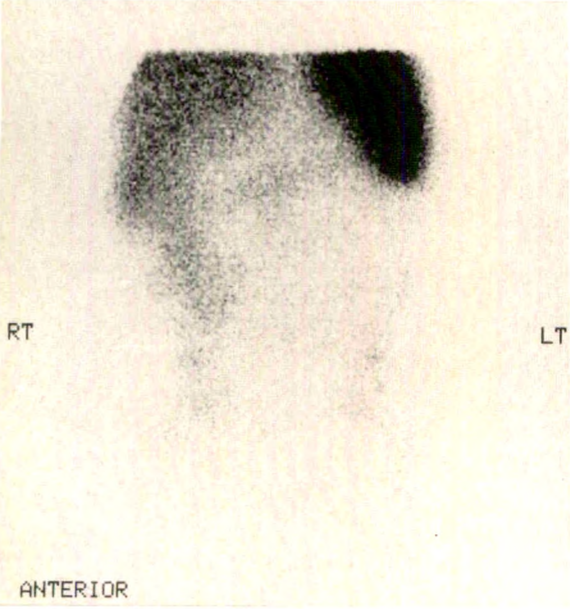

Figure 1. ^{111}In labelled white cell scan, 24 h image, showing increased activity in the region of the ascending colon.

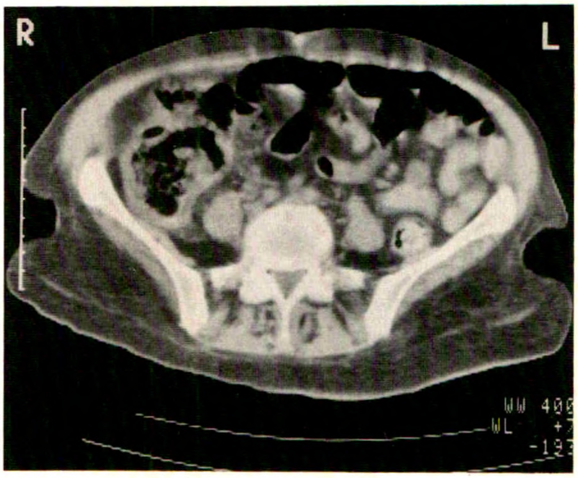

Figure 2. Section from abdominal CT scan. There is marked thickening of the ascending colon. No lymphadenopathy or ascites was evident.

Discussion

Strongyloides stercoralis is a nematode which is patchily endemic throughout the tropics and subtropics. It is acquired in its larval form via the skin. Unlike other nematodes, it is able to carry out multiple life cycles within the host's gastrointestinal tract. Thus the disease may manifest itself many years after the original infestation, often when the host becomes immunocompromised.

In light infections bowel symptoms are often mild or absent. Heavy infections will produce profuse painless diarrhoea. Often an overwhelming infestation is accompanied by gram negative septicaemia and disseminated intravascular coagulation.

Colitis in strongyloides infection has been reported in a number of papers (Berry et al, 1983; Carp et al, 1987; Drasin et al, 1976) but in each of these cases there have been prominent bowel symptoms and signs. In this patient there was no change in bowel habit, despite her intermittent abdominal pain. The presence of colitis was completely unsuspected prior to the radiological investigations.

At this stage the differential diagnosis of localized colitis in an immunosuppressed patient was considered. Ulcerative colitis and Crohn's disease have a reduced incidence in the immunosuppressed and were thought unlikely. Infective causes such as salmonella and amoebiasis are more common in the immunosuppressed; atypical mycobacterial infection, cryptosporidiosis and strongyloidiasis are almost completely confined to the immunocompromised.

Finally, there are direct complications of leukaemias, such as "typhlitis". This is a condition which normally is confined to the caecum and ascending colon, producing an active colitis. Perforation is common and there is some evidence that *clostridium septicum* is the aetiological agent. Plain radiographic findings in typhlitis include air in the bowel wall. Barium examination demonstrates diffuse ulceration with or without thumbprinting. Computed tomography, as in this case, shows gross bowel wall thickening (Bankoff et al, 1985; Taylor et al, 1985).

Fortunately in this case a rapid and specific diagnosis was made by stool microscopy.

The presentation following her course of chemotherapy was interesting and is typical of strongyloidiasis which has been reported in a number of cases to arise following immune suppression. (Pagliuca et al, 1988; Maayan et al, 1987) To our knowledge, the CT appearances of colonic strongyloidiasis have not previously been reported.

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Epidermoid cyst of the spleen: a case report and review of the literature

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True cysts of the spleen are rare, those caused by the parasite *Taenia ecchinococcus* accounting for over two thirds of the world's cases. In non-endemic areas, benign non-parasitic cysts prevail, and only 10 % of these are epidermoid. Pseudocysts, resulting from trauma, haemorrhage or infarct are four times as common as true cysts, the latter being defined as those with an epithelial lining.

Epidermoid cysts of the spleen usually present in the second to fourth decades, 60% are in females, 80% are unilocular and solitary and only 10% calcify (Robbins et al, 1978).

There are few reports of epidermoid cysts of the spleen in British radiological literature (Zimmerman et al, 1972; Bhimji et al, 1977; Daneman & Martin, 1982).

Case report

A 10-year-old Caucasian boy was transferred to The Hospital for Sick Children, Great Ormond Street with a 2-day history of abdominal pain, distension, retching and constipation.

The history dated back 4 months, when he presented to his general practitioner following a heavy and spontaneous epistaxis. After this he developed myalgia and polyarthralgia for which a diagnosis of reactive arthralgia was made. This slowly resolved with non-steroidal anti-inflammatory medication.

During investigation he was found to have splenic enlargement and ultrasound showed a well defined, relatively echo-poor lesion, 10 cm in diameter, arising from the spleen. This was thought to represent either a large splenic haematoma or haemorrhage into a splenic cyst (Fig. 1).

The patient admitted to having sustained a fall onto his left side 3 months previously. He was admitted for observation and his condition remained stable. A computed tomographic (CT) scan was performed which showed a 10 cm diameter, low density, non-enhancing mass medial to the spleen. Other abdominal organs were normal (Fig. 2).

The patient was discharged to his home for strict rest with planned monthly follow-up examinations and ultrasound scans. Events culminated in emergency admission as described. On admission he was well with no signs of circulatory embarrassment. The abdomen was soft with a palpable spleen 4 cm below the left costal margin. The ultrasound appearance was unchanged from the initial scan, and plain abdominal films confirmed an enlarged spleen together with normal bowel gas pattern.

At laparotomy a partial splenectomy was performed to include the splenic cyst. This was noted to contain non-haemorrhagic fluid, and histopathology showed a unilocular, coarsely trabeculated, fibrotic-walled cyst lined by stratified squamous epithelium adjacent to normal splenic tissue. Postoperative recovery was uneventful.

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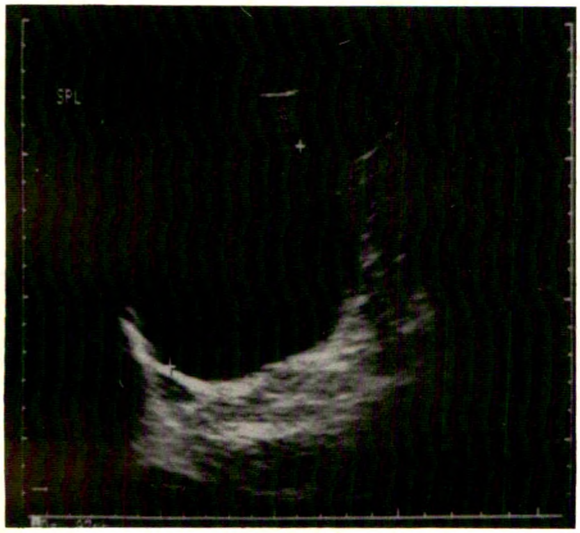

Figure 1. Ultrasound of spleen, showing a well defined 10 cm lesion.

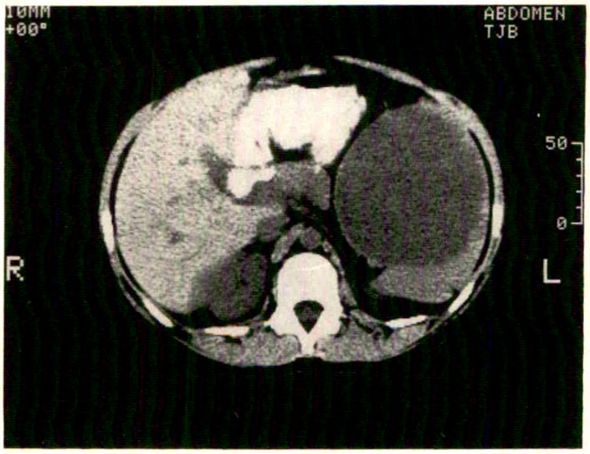

Figure 2. Computer tomographic scan of spleen, showing a 10 cm low density, non-enhancing mass.

Discussion

This case demonstrates one of the most common presentations, that of incidental finding of a solitary cyst. Twenty-five per cent are discovered after trauma which is often trivial and coincidental. Others present with a feeling of fullness or pain in the left upper quadrant. After haematological investigation has excluded other causes of an enlarged spleen, such as myeloproliferative and infective diseases, the diagnosis relies upon radiological assessment (Ross et al, 1977).

The aim of the pre-operative evaluation is to localize the mass to the spleen, assess whether it is cystic or solid and to exclude secondary splenic involvement by a primary systemic disorder.

Ultrasound is the most valuable single investigation for splenic epidermoid cysts, showing, as in this case, a well circumscribed echo-poor lesion not changing over a period of time. When the lesion is not completely anechoic, Goldfinger et al (1986) have advocated that splenic aspiration should be performed to exclude a neoplasm or lymphoma. The dangers are of rupture, peritonitis and seeding in hydatid disease. In non-endemic areas this risk is extremely small. Computed tomography will also demonstrate the nature of the lesion, but often no additional useful information is obtained. Nuclear medicine scans are generally non-specific and angiography will display an avascular mass with vessels stretched around it. This information can be particularly important in determining the feasibility of a partial splenectomy.

The advocated treatment is elective surgical removal of the cyst, conserving the spleen if possible, because of potential splenic infection, rupture following trauma, massive haemorrhage or abscess formation. Lippit et al (1967) report cases of rupture with severe localized granulomatous inflammation. Pre-operative pneumovac immunization should be given in case splenectomy is unavoidable.

Pathologically the epidermoid cyst is lined with pearly white trabeculations. Microscopically there are focal areas of stratified squamous epithelium in varying amounts. The aetiology is unknown but is thought to be congenital and current theories are of metaplasia of coelomic epithelium which is mesodermal in origin or a heterotopic endodermal inclusion within the spleen. Ahlgren and Beardmore (1984) have reported familial occurrence of solitary epidermoid splenic cysts and postulated a genetic transmission.

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Thin ribs, thin tubular bones, abnormal facies and intrauterine growth retardation: a lethal syndrome

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Two neonates with peculiar facies, thin ribs and thin long bones are presented. Both these cases had an otherwise uneventful antenatal period but died soon after birth. The two cases had no familial relation to each other.

Case reports

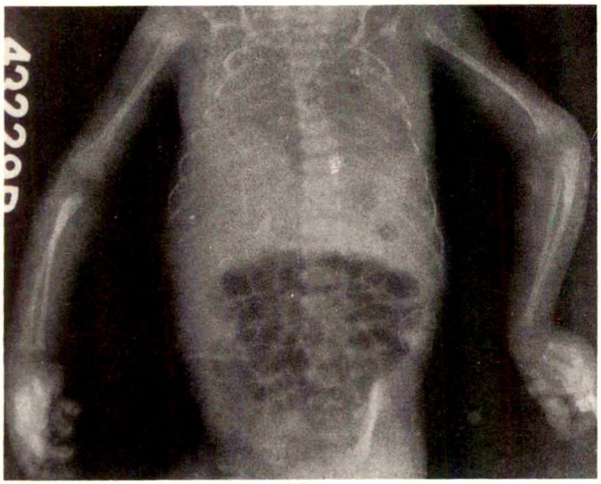
Case 1

A male baby was born at term by caesarean section to a booked second gravida mother with borderline contracted pelvis because of breech presentation. The Apgar score was 5, 6 and 6 at 1, 5 and 10 min, respectively. The neonate showed increasingly poor respiratory effort and died after 2 h. There was no history of maternal exposure to drugs or radiation. Ultrasound examination 10 days prior to delivery showed mild hydramnios.

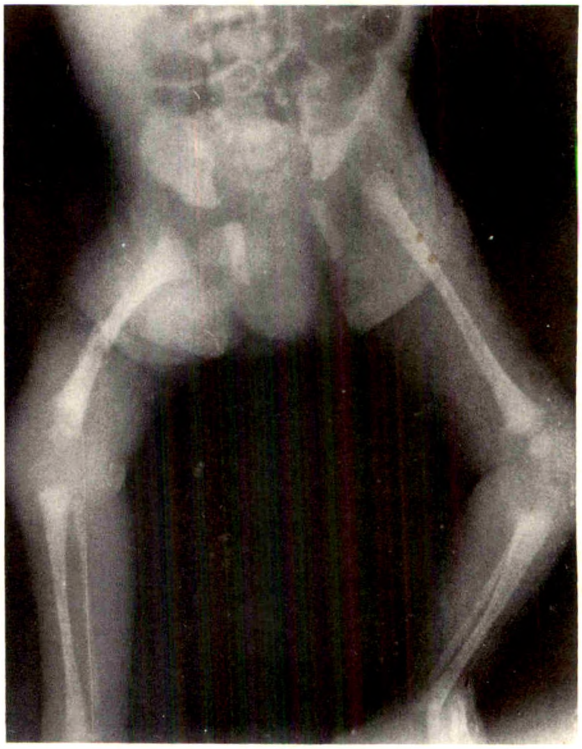
The newborn weighed 2.2 kg, with head circumference 35 cm, crown–heel length 49.5 cm and an upper segment to lower segment ratio of 1.4. There was frontal bossing with all three fontanelle widely open, low set ears, high arched palate and bilaterally undescended testes. Its extremities were thin and a palpable fracture of right femur was noted, but no contractures, syndactyly or camptodactyly were present. Post-mortem skeletal survey revealed thin string-like ribs and thin tubular bones (Fig. 1a). This case had narrow iliac wings, bilateral sloping acetabular roofs and dislocation of left hip. The ischia were vertical and one fracture of right femur was present at birth (Fig. 1b).

Case 2

A female neonate was delivered by an elective caesarean section (because of a placenta praevia) to a third gravida mother after 36 weeks of gestation. Ultrasound examination 3 days before delivery showed mild to moderate hydramnios and placenta praevia. An Apgar score of 4, at 1 min, improved to 6 and 7 at 5 and 10 min, respectively, following assisted ventilation. However, spontaneous efforts were poor, and the baby died 10 h after birth. The birth weight was 1.8 kg, crown–heel length 46 cm with an upper segment to lower segment ratio of 1.49, head circumference 34.5 cm and chest circumference



(a)



(b)

Figure 1. *Case 1.* (a) Extremely thin "fish-bone"-like ribs and very thin tubular bones. (b) Radiographs of both lower limbs: this antero-posterior view shows thin long bones with fracture of right femur.

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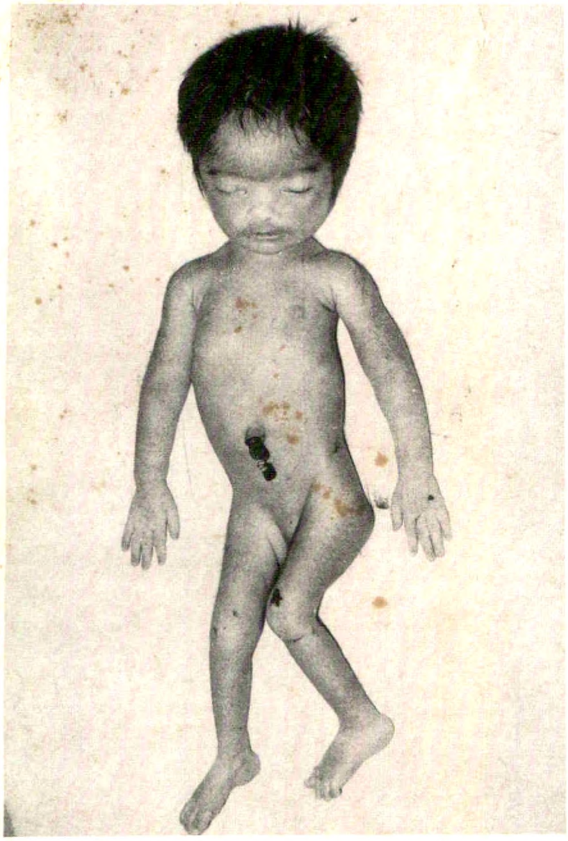

Figure 2. *Case 2.* Clinical photograph showing prominent forehead and eyebrows, low set ears and thin tapering fingers.

24 cm. The newborn had frontal bossing, prominent eyebrows, low set ears, micrognathia, high arched palate and arachnodactyly (Fig. 2). Both thumbs had three palmer creases. Post-mortem radiographs showed extremely thin ribs and thin long bones. This case also had narrow iliac wings and shallow acetabular roofs but no fracture (Fig. 3). The karyotype showed a normal pattern of 46 XX. Full necropsy was not permitted.

Discussion

The most peculiar features of our cases were extremely thin ribs, thin tubular bone and an otherwise inexplicable fatal outcome. Hydramnios was the only abnormality noted in antenatal period. Both had intrauterine growth retardation with abnormal facies but normal crown–heel length.

There is paucity of literature on thin ribs in the newborn. Thin ribs and thin bones are described in arthrogryphotic syndromes (Herva et al, 1985) and trisomy 18 (Majewski, 1981). Herva et al (1985) described seven cases with thin ribs and three cases with generalized thin tubular bones. All these cases with multiple contractures were preterm, either still born or live births, with fatal outcome. Absence of contractures and a normal karyotype in one case rule out the above two conditions.

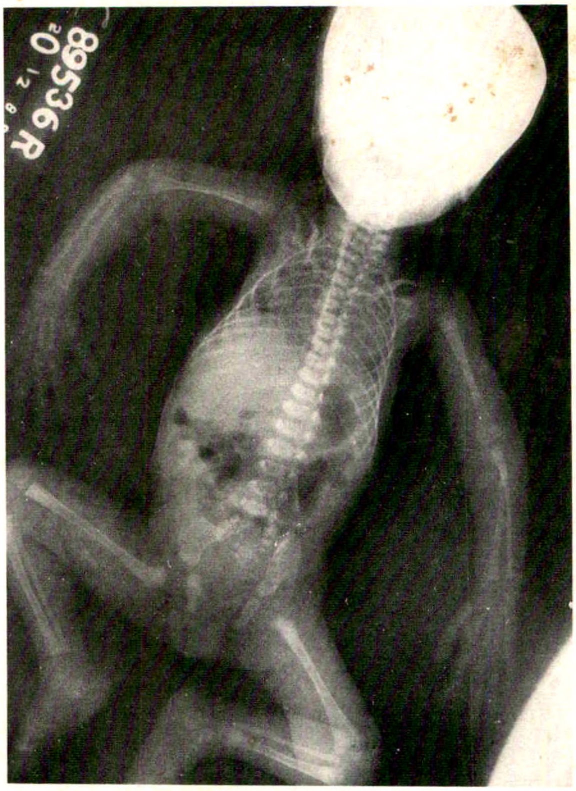

Figure 3. *Case 2.* Infantogram showing thin ribs and thin long bones with normal spine.

Very few other case reports match the radiological appearances of our cases. Kurlander et al (1966) described similar radiological features in a case of Hallerman–Streiff syndrome. Gravaleau et al (1973) reported a preterm dwarf with bilateral forearm fractures, thin ribs and thin tubular bones. No clinical photograph of the patient was however shown. Kozlowski and Kan (1988) reported three cases of which in one complete clinical notes were available: a 32-week preterm baby with peculiar facies and intrauterine dwarfism; no clinical details were reported for the other two cases. All these three cases had spectacular thinning of ribs and long bones with multiple fractures. Our cases most closely resemble these reports by Kozlowski and Kan (1988).

The combination of unusual radiographic appearances, abnormal facies, intrauterine growth retardation and hydramnios with apparently normal antenatal course but poor fetal outcome suggests a wider, lethal syndrome. Whether our cases represent the same entity as reported by Kozlowski and Kan or a different entity is not clear, since both our cases were near term with normal crown–heel length. However, further documentation of similar cases with more detailed clinical, radiological, karyotypic and pathological features would be required to define this condition. Fatal outcome may be due to poor respiratory efforts because of hypoplastic ribs and floppy thoracic wall.

Acknowledgments
We would like to thank Mr Bhagwan Das and Mr Sohan Rawat for their excellent photographic work.

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Macronodular hepatic tuberculosis in a child: computed tomographic appearances

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Hepatic tuberculosis (TB) is usually miliary, associated with pulmonary miliary disease. Large tuberculous hepatic abscesses are not frequently seen, and are extremely rare in children, in whom the overall incidence of hepatic TB is lower than in adults. The largest reported series of hepatic TB to date described 200 cases in all, of which only one case, an adult, demonstrated macronodular caseating abscesses (Hersch, 1964). This form of TB is usually seen in extremely debilitated patients with poor immunological resistance, which often serves to complicate the clinical picture and make the diagnosis difficult. In the case described, computed tomography (CT) proved invaluable in making the diagnosis and on follow-up.

Case report

A 4-year-old black male child presented to the Red Cross Childrens' Hospital in June 1985 with a 2-month history of weight loss, fever, vague abdominal pain and malaise. On examination he was clearly emaciated, pale, with a distended abdomen, ascites, nodular hepatomegaly, and pyrexial with a temperature of 38.5°C. Relevant biochemistry revealed a raised alkaline phosphatase (400 IU/l), the erythrocyte sedimentation rate (ESR) was 74 mm/h, he had a normocytic anaemia with haemaglobin level (Hb) of 6.9 g/l and a raised WCC of 15×10^9/l. Blood cultures were sterile and ascitic tap showed straw-coloured fluid, also sterile, with a total protein of 25 g/l. The chest radiograph showed non-specific patchy basal consolidation. A Mantoux (tuberculin) test was strongly positive.

Computed tomography of the abdomen (Fig. 1) confirmed hepatomegaly and ascites and revealed multiple rounded intrahepatic lesions of low attenuation measuring 1–2 cm in diameter, which showed rim enhancement after intravenous contrast. Large para-aortic and para-caval hypodense nodal masses were also identified, and similar lesions were also seen around the porta hepatis, splenic hilum, peri-pancreatic region, and in the mesentery.

The possibility of disseminated malignancy was considered, but rejected in favour of a diagnosis of abdominal and hepatic tuberculosis, based on the clinical findings, positive Mantoux, and suggestive CT appearances. The child was commenced on triple anti-tuberculous chemotherapy to which he responded dramatically, with resolution of abdominal tenderness, lysis of fever, and weight gain. He was subsequently discharged to his local hospital on chemotherapy, but was lost to follow-up.

Two years later (June, 1987), he re-presented to our institution with renewed symptoms of cough, night sweats, weight loss, abdominal pain and distension. Once again he was found to be anaemic, wasted and apathetic, with tender hepatomegaly and ascites. He now had cervical and inguinal lymph node enlargement. Liver biochemistry was again abnormal with a raised alkaline phosphatase (300 IU/l), the ESR was 70 mm/h, Hb 7.3 g/l, and WCC 18×10^9/l. Blood cultures, gastric washings and ascitic fluid were all sterile. A chest radiograph showed right upper lobe consolidation and bilateral hilar lymph node enlargement. An unenhanced CT scan of the abdomen (Fig. 2) revealed multiple calcified densities throughout the liver, with coalesced and calcified para-aortic, perisplenic and mesenteric nodes. Retrocrural lymph node enlargement was also noted (arrowed Fig. 2a).

In view of the clinical and radiological findings, the diagnosis of a generalized reactivation of abdominal tuberculosis was made, with new pulmonary involvement. The patient was therefore recommenced on antituberculous chemotherapy, as well as a high protein diet, haematinics and vitamins. Four months later he was generally much improved, had gained 5 kg in weight, and his abdominal and pulmonary symptoms had resolved. He remained well a year later.

Discussion

The overall incidence of tuberculosis (TB) is declining in the Western world where the major risk factors now

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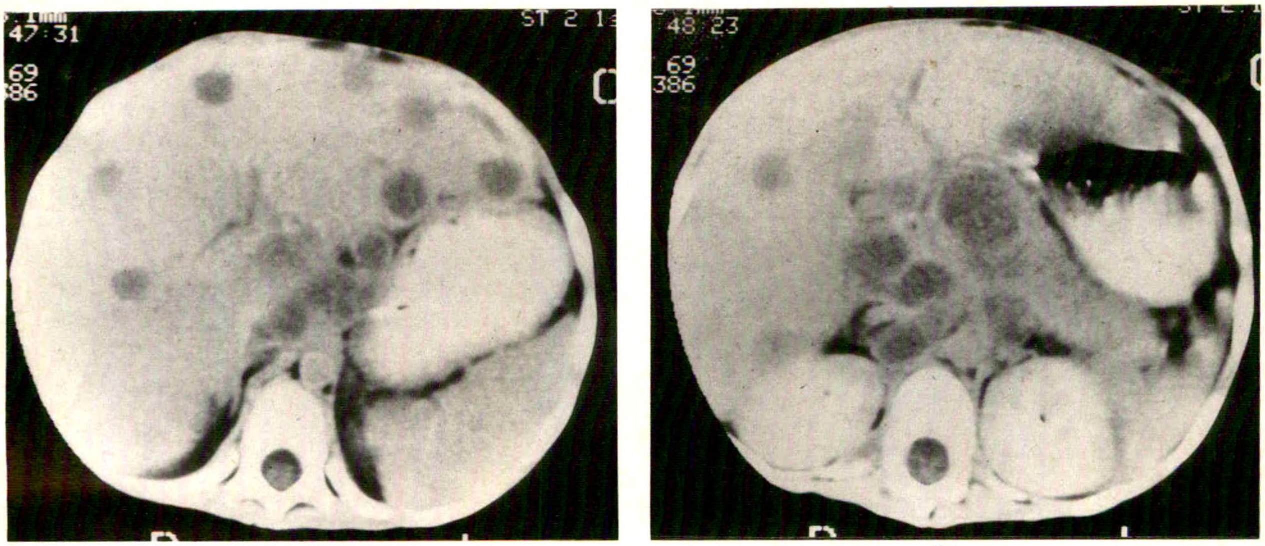
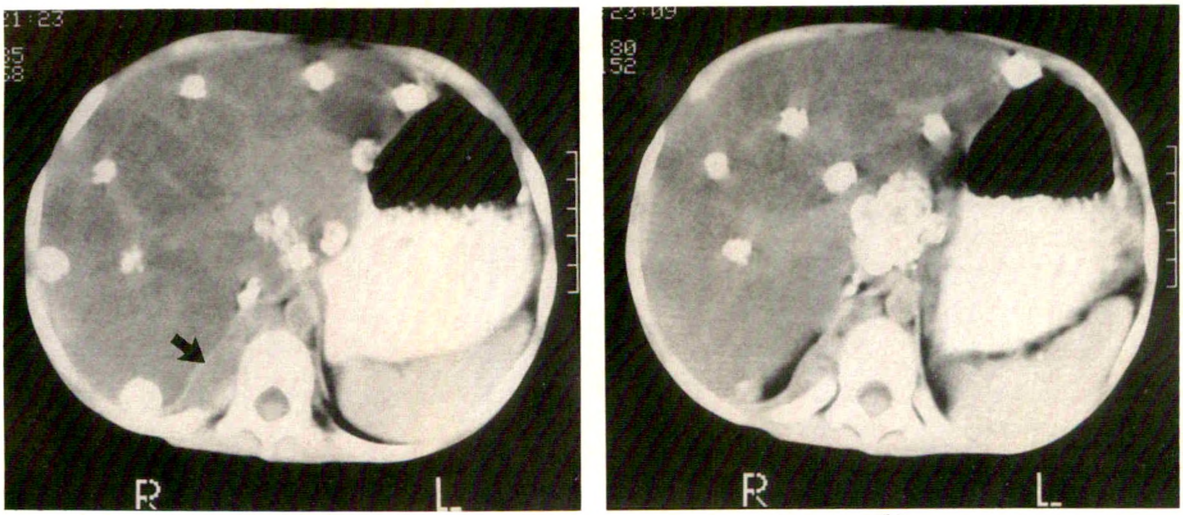


(a) (b)

Figure 1. Computed tomographic scans through upper abdomen (following intravenous contrast) showing multiple hypodense intrahepatic abscesses with rim enhancement. Similar low-attenuation lesions are seen within the porta hepatis, para-aortic and para-caval and peri-pancreatic regions.

include immunosuppression (including AIDS), intravenous drug abuse, cirrhosis, alcoholism, steroid therapy, diabetes, neoplasia, and immigration from endemic areas (Halnick et al, 1985). In developing countries TB still constitutes a major health problem, being associated with malnutrition and poor socio-economic status. In children the mortality is high if additional kwashiorkor or measles coexist (Johnson et al, 1987).

Abdominal TB generates a varied spectrum of clinical and radiological appearances, often requiring a high index of suspicion for diagnosis. Symptoms and signs can be non-specific and insidious, and may mimic malignancy, with weight loss, abdominal masses and ascites (Teh et al, 1987). The chest radiograph may be normal in up to 50% of cases (Hersch, 1964; Zipser et al, 1976) and, as in the case described, the tubercle bacillus (acid-fast bacteria) may never be cultured despite repeated sampling of stool, sputum, ascites, gastric washings, or even liver biopsy. Skin testing may also prove unhelpful if the patient is anergic (Korn et al, 1959).



(a) (b)

Figure 2. Unenhanced CT scans taken 2 years later at similar abdominal levels showing calcification within the previous hepatic abscesses, and within para-aortic, portal and peri-pancreatic lymph nodes, which have reduced considerably in size. New retrocrural lymphadenopathy is now evident on the right (arrowed Fig. 2a).

Liver involvement is common in miliary TB, being present in up to 80% of cases, but isolated hepatic disease is rare, particularly in children (Hersch, 1964). Macronodular tuberculous liver abscesses, measuring some centimeters in diameter occur infrequently, representing coalescence with central caseation of tuberculous granulomata which contain an abundance of acid-fast bacteria. The patients are usually debilitated with poor general immunity (Korn et al, 1959; Hersch, 1964; Zipser et al, 1976). The source of infection is thought to be a bowel lesion, often ileocaecal, with spread via portal lymphatics to the liver (Ashton, 1946; Hersch, 1964). This contrasts with the miliary form of hepatic TB which is spread haematogenously.

The liver abscesses are generally found in association with caseating lymphadenopathy elsewhere in the abdomen, such as in the mesentery (particularly around sites of gut involvement), in the para-aortic region, the retroperitoneum, retrocrurally, and around the pancreas and splenic hilum; the spleen itself may be involved (Ashton, 1946; Zipser et al, 1976; Epstein & Mann, 1982; Dahlene et al, 1984; Hulnick et al, 1985; Deutch et al, 1987). Ascites of variable but often high protein content is usually present. On healing, the hepatic and nodal lesions show calcification and fibrosis.

The CT findings in active abdominal TB include complex high density ascites (the density relates to the ascitic protein content), low density nodal masses with enhancing rims, irregular omental masses, and peritoneal enhancement (Epstein & Mann, 1982; Dahlene et al, 1984; Hanson & Hunter, 1985; Hulnick et al, 1985; Zirinsky et al, 1985; Mathieu et al, 1986; Deutch et al, 1987). Macronodular intrahepatic abscesses have previously been described using CT, showing low density masses with peripheral enhancement, but to date there have been no such reports in children, nor any with follow-up (Hulnick et al, 1985).

Whilst the varied manifestations of abdominal TB are well known (Hersch, 1964; Epstein & Mann, 1982; Teh et al, 1987) the CT appearances are also not pathognomonic. The term "pseudotumoral" has been used to describe the macronodular hepatic disease, since the presence of a large nodular liver and ascites in a wasted patient invokes the clinical diagnosis of disseminated malignancy. Cirrhosis may also give similar appearances. The differential diagnosis on CT includes pyogenic and amoebic abscesses, necrotic metastases and lymphoma. The presence of widespread low-attenuation nodal disease within the abdominal cavity suggests lymphoma, and other malignancy such as metastatic testicular teratoma, and some benign conditions such as Crohn's and Whipple's disease (Zipser et al, 1976; Epstein & Mann, 1982; Dahlene et al, 1984; Deutch et al, 1987).

In the case described the child was initially thought to have malignant disease, but the high incidence of TB within the poor communities in South Africa made TB a more likely diagnosis despite the persistent inability to culture tubercle bacillus. When the patient re-presented some 2 years later, both the hepatic lesions and diffuse abdominal nodal disease had regressed and calcified causing the striking changes on CT scanning. However, he still had abdominal pain and ascites, and had clearly developed new pulmonary involvement with additional peripheral lymphadenopathy, implying continuing systemic disease.

Whilst the diagnosis of hepatic tuberculosis may be made more readily in parts of the world where the disease remains common, in the Western world it may be overlooked, even in the "high risk" groups mentioned earlier. The combination of clinical findings with suggestive CT images as described should raise this possibility, even though acid-fast bacteria may never be isolated. The importance of establishing the correct diagnosis cannot be overstated, since untreated abdominal TB carries a 50% mortality rate (Hulnick et al, 1985), whereas with effective treatment, the prognosis is very good.

Acknowledgment

My thanks go to Professor Bryan J. Cremin for permission to publish this case report.

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1990, *The British Journal of Radiology*, *63*, 659–660

Case of the month

The forgotten incident

By *T. L. Tran, FRCS(Eng), DMRD, FRCR and M. McCarty, MB, BS, MRCP

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(*Received January 1989*)

A 47-year-old man was referred by his general practitioner to the medical outpatient clinic with a 4-week history of colicky abdominal pain in the epigastrium and peri-umbilical region, anorexia and weight loss. He also complained of flatulence and abdominal distension after meals. The only relevant past medical history was bilateral inguinal hernia repairs 12 months previously.

Abdominal examination in the outpatient clinic did not reveal any abnormality. His complaints were thought to be related to gall bladder or peptic ulcer disease. Initial investigations included an upper abdominal ultrasound which was normal. Two weeks later, the patient attended for a barium meal. Although the oesophagus, stomach and duodenum were normal, multiple dilated loops of small bowel were seen on screening. A barium follow-through examination was then carried out. The findings are illustrated in Figs 1 and 2. There was a tight stricture in the distal ileum leading to small bowel obstruction.

What is your provisional diagnosis?

What further clinical history should be sought?

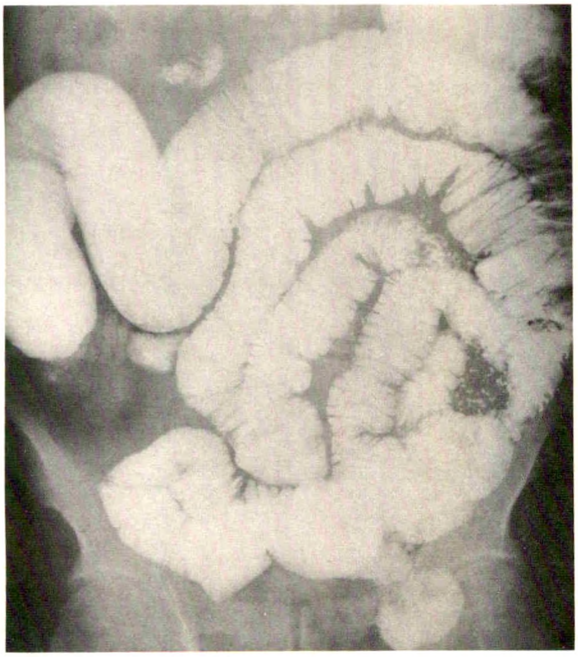

Figure 1. Abdominal radiograph of a barium follow-through study demonstrates a tight stricture in the distal ileum. Incidentally, there is a recurrent inguinal hernia on the left side.

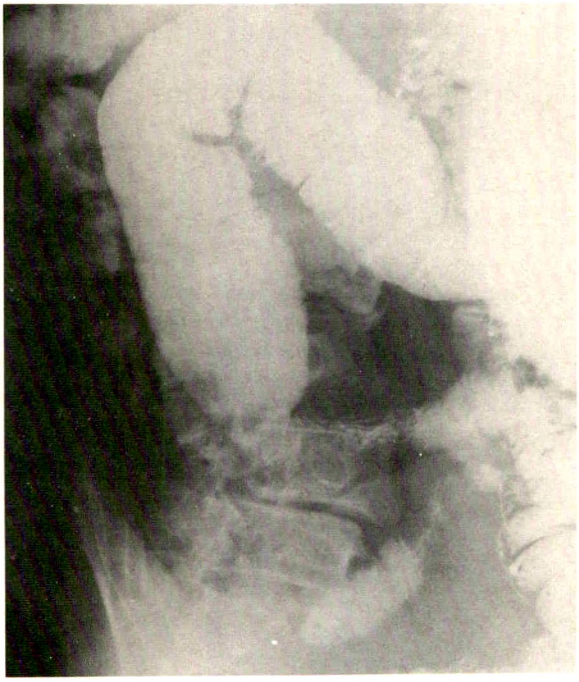

Figure 2. Further delayed film demonstrates barium filling the terminal ileum and colon.

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The barium follow-through study demonstrates a short segment of narrowing in the distal ileum with gross dilatation of the small bowel proximal to it. The stricture showed abrupt tapering with mucosal irregularity, and there appeared to be a mass in the right iliac fossa associated with it. In view of the small bowel obstruction, the patient was referred directly from the radiology department to the surgical team for further management. Examination of the abdomen this time revealed a mass in the right iliac fossa and obstructive bowel sounds. The provisional differential diagnosis was carcinoid tumour of the small bowel, carcinoma, Crohn's disease or adhesions due to previous hernia repairs.

A laparotomy followed. In the right iliac fossa, the ileal stricture was found to be encased in a fibrous mass to which the sigmoid colon was also adherent. The mass together with 10 cm of the sigmoid colon and the encased loop of ileum were excised. On histology, the small bowel was found to be tethered to the sigmoid colon and sharply bent on itself. At the point where it was tethered, there was a 2 cm perforation in the sigmoid colon with an abscess cavity, measuring 1.5 cm × 1 cm × 1 cm. The abscess had extended into the wall of the small bowel and the overlying mucosa was ulcerated. There was no other bowel pathology such as diverticular disease or tumour in the sigmoid colon to account for the perforation.

In the light of these findings, specific enquiry revealed that, 1 week before the onset of his presenting symptoms, he had been kicked in the lower abdomen during an assault. Although he had pain in that region initially, it quickly subsided and the incident was not disclosed to his general practitioner. As the site of injury and the site of pathology were well correlated, trauma was assumed to be the cause of the bowel perforation.

Discussion

The differential diagnosis of a small bowel stricture would include adhesions, Crohn's disease, carcinoid tumour, carcinoma, lymphoma, metastasis, ischaemia and trauma. Adhesions are the most common cause of small bowel obstruction, even in patients who have not had an operation. The latent small bowel obstruction in our case is due to colonic perforation with subsequent sealing by adjacent tissue and adhesions.

Delayed intestinal obstruction due to bowel strictures is an infrequent sequel of blunt abdominal trauma and may manifest at variable time after the initial injury. Raf (1969) reviewed a series of 95 benign bowel strictures reported over a period of 12 years and found only one report of post traumatic stricture. The underlying pathophysiological mechanisms of delayed bowel obstruction include bowel ischaemia, contusion of the bowel wall, intramural hemorrhage and/or bowel perforation with fibroblastic reaction. These factors, alone or in combination, result in cicatricial narrowing of the bowel wall and/or adhesions with resultant mechanical obstruction. Other mechanisms are mesenteric or diaphragmatic disruption with subsequent internal hernia and serosal contusion resulting in adhesions.

The mechanism of blunt trauma to the bowel is compression with shearing between two surfaces such as the spine and the abdominal wall (Williams & Sargent, 1963). Bowel rupture occurs when intestinal wall tension exceeds its bursting potential because of rapidly displaced intestinal content. The most frequently damaged bowel and associated mesentery are the duodeno-jejunal junction, the proximal and terminal ileum, and the transverse and sigmoid colon because the peritoneal fixed points place these segments of bowel over the spine (Martin et al, 1960). A similar mechanism may account for the types of injury associated with the lap-type seat belt, sustained in automobile collision (Witte, 1968).

Finally, in patients with complete or partial intestinal obstruction, a history of blunt abdominal trauma may remain occult and is not often considered in the differential diagnosis. As a result of the increasing incidence of blunt trauma in our society, patients, presenting with complete or incomplete bowel obstruction with no previous history of abdominal operation, should be questioned about previous episodes of blunt abdominal trauma.

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(The Editors do not hold themselves responsible for opinions expressed by correspondents)

A localized hypersensitivity reaction to co-trimoxazole in a previously irradiated field simulating a recall phenomenon

THE EDITOR—SIR,

We read with interest the report of Atahan et al (1989) on an enhanced skin reaction in a previously irradiated site following administration of co-trimoxazole. In this journal we have reported previously a case where an enhanced skin reaction in a previously irradiated area occurred following a generalized skin reaction to aminoglutethimide, a hormonal agent used in the treatment of breast cancer (Williams & Leslie, 1987). We suggested then that the irradiated skin had been rendered more susceptible to any subsequent insult and that this was the mechanism for the observed reaction rather than a true radiation recall reaction as has been described with certain cytotoxic drugs (Hellman, 1985). This could also apply to the case reported by Atahan et al and it is interesting that in their case the reaction also affected the skin of the arm which whilst not irradiated would possibly have been rendered susceptible by impaired lymphatic drainage.

Yours, etc.
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(*Received January 1990*)

(*Authors' reply*)

THE EDITOR—SIR,

In our article (Atahan et al, 1989) we described a case of local hypersensitivity reaction to co-trimoxazole* (Trimethoprim 160 mg—sulphamethoxazole 800 mg) developing 3 years after post-operative irradiation of an infiltrative ductal breast carcinoma. This reaction, being mainly confined to the irradiated chest wall and internal mammary regions, looked to be similar to the local reactions limited to pre-irradiated fields met with in recall phenomenon.

Leslie and Williams, in their comment on our article, are attracting the attention to a similarity between our case and a case of their own (Williams & Leslie, 1987). We think that the major difference between the two cases is that they observed an enhanced reaction of the region irradiated by ortho-voltage 300 Kv X-rays as a part of a generalized reaction to aminoglutethimide, and also that it developed very shortly (2 months) after the termination of radiotherapy where even the subacute skin reactions would not have been possibly subsided.

We are pleased to learn that they are in agreement with our explanation of the reaction in the non-irradiated left arm's skin, being caused by the impairment of lymphatic drainage.

Yours, etc.,
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Complete remission of metastatic squamous carcinoma after cisplatinum chemotherapy without sustained control, following primary tumour control by californium-252 brachytherapy

THE EDITOR—SIR,

The case report by Burnet and Blake (1989), "Sustained complete remission of Stage IV carcinoma of the cervix with cisplatinum, methotrexate and bleomycin chemotherapy", was of great interest. We have found californium-252 (Cf-252) neutron brachytherapy (Cf-NT) to be highly effective for local control of bulky T4 squamous cell carcinoma of the tonsil-oropharynx (Maruyama, 1984). Hence, we tested Cf-NT with adjuvant cisplatin-based chemotherapy for treatment of a case of advanced and metastatic oral cavity squamous cell cancer. Cisplatin plus 5-fluorouracil is an effective combination (Decker et al, 1983; Campbell et al, 1987; Toohill et al, 1987; Taylor et al, 1989), which we used. Recent studies in head and neck cancer had suggested cisplatinum-based agents would be effective (Davis & Kessler, 1979; Decker et al, 1983; Drelichman et al, 1983; Vogl et al, 1985; Williams et al, 1986; Campbell et al, 1987; Head and Neck Contracts Program, 1987; Toohill et al, 1987; Schuller et al, 1988; Cognetti et al, 1989; Taylor et al, 1989; Urba & Forastiere, 1989). We also observed a similar response with metastatic head and neck cancer, as reported by Burnet and Blake but remission was followed by relapse, further progression and ultimately failure, despite local control of the primary tumour.

Case report

A 62-year-old white male presented with a Stage IV squamous cell carcinoma of the left tonsil which involved the retromolar area, half the tongue, oropharynx and extended caudad and inferiorly to the posterior third of the tongue and down to the vallecula on the homolateral side. He had a lymph node of the upper left neck measuring 5 cm in diameter.

Clinical and computed tomographic examination revealed a large tumour involving the left tonsillar fossa, tongue and oropharynx down to the vallecula and measuring 8 × 10 × 6 cm in size which expanded the posterior third of the tongue to the midline. He had a left neck node that measured 5 cm in diameter. The patient was staged as Stage IV squamous cell carcinoma of the tonsil-oropharynx with tongue and hypopharynx extension.

The initial treatment was a Cf-252 implant to the tongue-

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*Bactrim forte tablet (Roche).

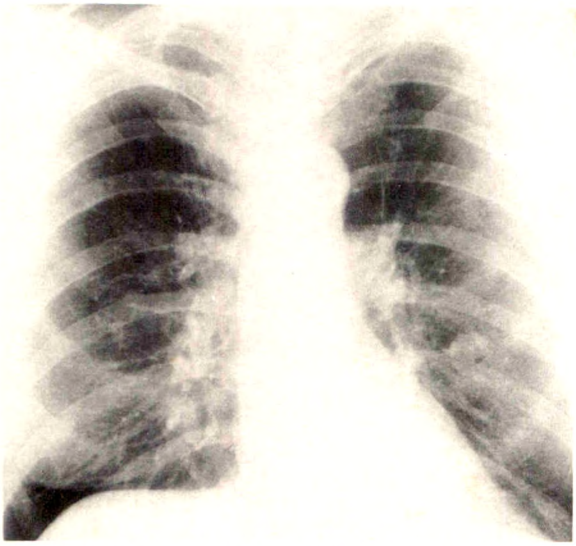

Figure 1. Radiograph showing partial regression of pulmonary nodules.

tonsil-oropharynx (Maruyama, 1984) done on June 5, 1985. Three interstitial tubes and one curved oral tandem containing Cf-252 were in the oropharynx with a treatment duration of 4½ hours and 1350 cGy-equivalents (cGy/eq) delivered. Cobalt-60 radiation therapy commenced immediately after the implant and was continued to 53 Gy to lateral opposed oropharyngeal portals and 50 Gy to the yoke portal. He received a second Cf-252 implant on July 22, to a remarkably regressed tumour, and two oral tubes were inserted to deliver a dose of 1500 cGy-equivalents to the tumour in the tonsil-tongue-oropharynx. Total dose to the tumour was 8150 cGy/eq.

There was tumour regression with therapy. Radiographic follow-up showed that the patient had developed a pulmonary nodule in the left paracardiac region which had progressed by subsequent follow-up, and there was marked progression and increase in the number of pulmonary nodules. The patient received therapy with cisplatinum-5-fluorouracil. He received nine cycles from 1985 to 1988. There was regression of pulmonary nodules (Fig. 1) after the initial course. However, ultimately he had progression of disease after initial CR–PR response. With multiple cycles of cisplatinum-5-fluorouracil, he had partial response to each treatment, but ultimately he became unresponsive to chemotherapy.

In October 1988 the patient developed brain metastases and received 36 Gy in 18 fractions in 2½ weeks to the whole brain. The patient died of progressive disease in November 1988. At autopsy, there was no tumour in the tongue or oral cavity, but there were metastatic deposits in the lungs and brain.

Discussion

The paper by Burnet and Blake (1989) notes a very unusual and rare solid tumour sensitivity to chemotherapy. Local control of oral-pharyngeal tumour in our patient was achieved by Cf-NT. Response of lung metastases in our patient was similar and there was tumour response for a period of 3 years. Ultimately, however, there was progression and failure of control of the lung metastases with the pulmonary metastases showing growth, progression, and resistance to chemotherapy.

Cisplatinum has been combined with other agents for the treatment of squamous cell carcinomas of a variety of sites (Urba & Forastiere, 1989). While regression response has been observed regularly, it has not significantly altered the survival (Toohill et al, 1987; Schuller et al, 1988) of the head and neck cancer patient (Urba & Forastiere, 1989). Probably the most useful observation from the use of chemotherapy, has been that tumours that do respond may also be sensitive to radiotherapy (Urba & Forastiere, 1989). While we agree that the way ahead for patients with advanced metastatic disease requires effective adjuvant chemotherapy regimens (Davis & Kessler, 1979; Decker et al, 1983; Drelichman et al, 1983; Vogl et al, 1985; Williams et al, 1986; Campbell et al, 1987; Head and Neck Contracts Program, 1987; Toohill et al, 1987; Schuller et al, 1988; Cognetti et al, 1989; Taylor et al, 1989; Urba & Forastiere, 1989), the single case report is misleading because it suggests that such treatment should lead to better survival and greatly improved cure rates when used either alone or in combined chemo-radiotherapy protocols. In fact, combined chemo-radiotherapy has not been shown to offer better cures or survival than radiation alone by clinical trials for squamous cell carcinoma to date (Toohill et al, 1987; Schuller et al, 1988; Taylor et al, 1989; Urba & Forastiere, 1989). Even when combined with very effective therapy which achieved local tumour control, distant metastases continued to be the cause of ultimate failure. While we share the authors hopes, we believe that the case reported by Burnet and Blake and our case represent unusual tumour sensitivity and response to chemotherapy, which are more likely to result from idiosyncratic tumour sensitivity.

Yours, etc.
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The traceability of brachytherapy sources supplied by Amersham International

THE EDITOR—SIR,

The NPL has received several enquiries concerning the traceability route to national standards for brachytherapy sources. The purpose of this note is to describe briefly the current traceability links for brachytherapy sources and to outline measures that are planned to reinforce and formalize these linkages.

The first line of traceability for Amersham International's cobalt-60 sources is in terms of the quantity activity. Reference sources have been compared ionometrically with a base standard of cobalt-60 whose activity was measured by absolute counting at NPL. The 'output' (*i.e.* the exposure or air kerma rate at 1 m) of the base standard was calculated from the measured activity and associated energy fluence, making allowances for gamma ray absorption in the capsule, in the material itself, and in air. Radium-226 sources have been treated similarly, the activity being determined by comparison with the British National Radium Standard.

Two additional methods have been used to confirm traceability to national standards of source 'output'. The first, used for both cobalt-60 and caesium-137, involved ionometric comparisons with a standard radium-226 source, and the second the measurement of the exposure rate of sources in a scatter free area at NPL using a large volume chamber directly calibrated against the national primary standard of exposure (Read et al, 1978). This second exercise has recently been repeated and the results will be reported.

Amersham measures sources routinely by ionometric comparison with standard sources using a re-entrant ionization chamber.

Formal traceability of measurements made by Amersham on a range of radionuclide sources is established through their accreditation to NAMAS (the National Measurement Accreditation Service). Amersham is in the course of applying to have this accreditation extended to include brachytherapy sources. Accreditation is made against published criteria and includes an in-depth assessment and check of traceability links and related quality assurance measures. When the company becomes formally accredited to NAMAS for brachytherapy source calibration an annual audit check on the associated measurements for these sources will be made by NPL.

The NPL is discussing with the BIR and IPSM the possible wider use of the NPL secondary standard radionuclide calibrator in hospitals to facilitate routine comparison measurements between sources—essentially as an additional QA check. This would allow, for example, an Amersham source certified through NAMAS to be compared by a user straightforwardly with other sources, without the practical difficulties of making free-in-air measurements. The possibility of hospitals using the NPL radionuclide calibrator to make estimates of air kerma rate will also be considered. To gauge the users' requirements, a survey will be conducted through the BIR/IPSM, to establish *inter alia* the availability of NPL or other calibrators in radiotherapy departments, and the range of brachytherapy sources most commonly used.

It is hoped that the proposed scheme of formalized accreditation, regular audit measurements by NPL staff, together with check measurements by users will provide the additional assurances requested concerning brachytherapy source measurement traceability.

Yours, etc.,
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(*Received February 1990*)

Reference

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Testing a policy for skull radiography (and admission) following mild head injury

THE EDITOR—SIR,

I was very interested to read a recent article, "Testing a policy for skull radiography (and admission) following mild head injury" (de Lacey et al, 1990). It occurred to me that it might be an interesting exercise to cost out the financial implications of abandoning our "loose and liberal" policies on skull radiography and the impact of doing that on the hospital admission rate.

Dr de Lacey and his colleagues tell us that over a 2-month period by applying the Harrogate Criteria strictly, there could have been a reduction in skull radiographs of 36% in adults and 47% in children (with 261 adults and 160 children being X-rayed in total over that period). This gives us a total of 169 "unnecessary" skull radiographs over this period. Using a cost of £10.57 per standard three film skull series (costing exercise, Guy's Hospital, Department of Diagnostic Radiology, 1988) and allowing for inflation at the rate of 8% per year, this gives a total saving over the 2-month period of £2083.

Our Northwick Park colleagues tell us moreover that, although 17 people were admitted who should not have been admitted, strict application of the criteria would have resulted in 30 patients being admitted over that period; giving a net increase of 13 admissions. Allowing an overnight admission cost of £185, this would result in extra spending of £2405. A total extra cost of £322, or 76 pence per patient.

These costs are approximate, of course, and will vary from Hospital to Hospital; presumably, however, the differential will be preserved.

Seventy-six pence per patient does not seem a lot to pay for the practice of good medicine.

Yours, etc.,
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(*Received February 1990*)

Reference

de Lacey, G., McCabe, M., Constant, O., Welch, T., Spinks, C. & McNally, E., 1990. Testing a policy for skull radiography (and admission) following mild head injury. *British Journal of Radiology, 63*, 14–17.

Vasopressin release in response to intravenously injected contrast media

The Editor—Sir,

The hypothesis of Trewhella et al (1990) that the renal vascular response of contrast media (CM) is mediated by vasopressin is interesting. However, we have recently demonstrated that CM can exert a direct effect on renal vascular resistance (RVR) independent of the influence of systemic hormones using the isolated perfused rat kidney model (El Sayed et al, 1990). In this model, the isolated rat kidney is perfused with cell-free physiological solution, to which CM can be added, allowing the study of their direct effects on the kidney independently from their systemic influences. We observed an increase in RVR with different high and low osmolar CM and the magnitude of this response was not directly proportional to the osmolarity of the tested agents.

Whilst vasopressin may have a contributory role in the pathogenesis of increased renal vascular resistance in response to CM *in vivo*, we have shown that his response can occur independently of systemic hormones. The pathophysiology of renal vascular response of CM remains to be established and is currently under investigation in our research laboratories.

Yours, etc.
S. K. Morcos
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(*Received February 1990*)

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Proceedings of the British Institute of Radiology

Quantification in imaging—what is it and what is its future?

Abstracts of papers presented at a meeting of the BIR at 36 Portland Place, London W1N 4AT, on Wednesday, 21 February 1990

Part I: What does quantitative imaging mean to the clinician?
Chairman: Dr W. Hately

Quantitative imaging in radiotherapy, by D. Tait
Obstetrics and gynaecology, by S. Campbell. Abstract not received
Cardiology, by D. Gibson. Abstract not received
Quantitative imaging and the surgeon, by G. H. Westbury
Quantitative imaging in oncology—clinical requirements, by S. Meller
Neurology, by M. Swash. Abstract not received

Part II. What may quantitative imaging gain from science and technology; now or in the near future and longer term
Chairman: Dr R. Speller

Ultrasound, by P. N. T. Wells
Quantitative digital angiography, by D. H. Hawkes and M. T. Arnold
Quantitative imaging in magnetic resonance, by M. O. Leach
Quantitative imaging in computed tomography, by K. Faulkner
Nuclear medicine, by T. Jones. Abstract not received

Part III: Proffered papers
Chairman: Prof. C. R. Hill

Textural analysis in quantitative magnetic resonance imaging of metabolic bone disease, by X. P. Zhu, R. W. Whitehouse, J. E. Adams, I. Isherwood, J. P. R. Jenkins and P. H. Adams
Quantitative computed tomography for vertebral trabecular fat estimation, by R. W. Whitehouse, J. E. Adams, P. H. Adams and I. Isherwood
Clinical and experimental evaluation of a method for iodine quantitation using digital flourography, by J. P. Owen, C. J. Kotre, W. Thompson, K. Faulkner and R. M. Harrison
Cerebral vascular reserves in acute ischaemic stroke, by A. R. Naylor, M. V. Merrick, R. J. Sellar, T. M. J. Griffin, C. P. Warlow and P. A. G. Sandercock

Part IV: Where do we go from here? What are the priorities and strategies for R & D?
Panel discussions with audience participation.
Chairman: Dr D. Rickards

Panel: P. J. Ell, P. Vernon, G. Dombrowe, W. Lees, I. Isherwood and I. Young

Quantitative imaging in radiotherapy

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Quantitative imaging has become an integral part of the new technology which is revolutionizing radiotherapy practice. Three-dimensional treatment planning has been made accessible by the application of computer technology to imaging systems to date mainly using computed tomography but with increasing interest being shown in magnetic resonance imaging. This, together with computer control of the treatment machine parameters, has introduced conformal therapy on a practical basis. In this, the high dose treatment volume is made to conform more closely to the defined "tumour" volume than has previously been possible. However, the successful application of this development obviously relies on accurate tumour localization and measurement. A presumed advantage is the reduction in the volume of surrounding normal tissue that need be included in the high dose zone. In order to evaluate this potential benefit it is necessary that normal tissue volumes can be accurately measured and compared. For example, The Royal Marsden Hospital is undertaking a trial comparing new, with standard, technology in radiotherapy of pelvic tumours. This requires measurement and comparison of bowel volumes using both techniques in every patient. Although most standard radiotherapy practice can be carried out without absolute tumour volume measurement, there are a number of areas of research where this is a vital component. For example, the probability of tumour control can be a function of tumour size and for accurate assessment of this, tumour dimensions must be known. Also, response rates during and following radiotherapy are sometimes employed to assess and compare the effectiveness of the treatment regimes. To do this, it is essential that serial tumour measurements are made and a true rate of change of size calculated. Time to complete response or response assessment at a given time cannot provide information on rate of response.

Quantitative imaging and the surgeon

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Surgeons welcome information which refines the indications for surgery, enhances its accuracy or ideally avoids it where appropriate. Pre-operative diagnosis is reached by a combination of many inputs, including the data from imaging. The surgeon needs to know the precise site and anatomical extent of a lesion, its size, the number of lesions, the pathological nature of the condition and, in some circumstances, the physiological state of an organ. Precision in enumeration of the above parameters is essential for diagnostic accuracy and it is hoped that more precise quantitation will be forthcoming with developments in imaging technology.

Quantitative imaging in oncology—clinical requirements

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The first clinical question the oncologist asks is whether a tumour is a cancer, which is ultimately determined by histopathology, although the presence of metastases in advanced cancer may render the histopathology relatively less important. Imaging is increasingly specific in terms of tissue characterization, but differentiation between cancer and inflammation can still prove impossible. A combination of techniques (*e.g.* ultrasound + radioimmunoscintigraphy + MRI) may increase the specificity of cancer diagnosis. Baseline measurements of size, location and tissue signature, possibly supplemented by measurements of tumour metabolism, blood flow and heterogeneity place the clinician in the best position to assess response to chemo/radiotherapy: not all these measurements are exploited in routine clinical practice, perhaps because micrometastatic disease remains beyond the reach of imaging devices. Nevertheless, these techniques are important in a research setting to assess response to new therapies. Audit of imaging would help clinicians to choose the "best buy" and the importance of multimodality co-operation and standardization of quantitative techniques for inter-institutional comparisons could reduce the subjectivity of some of the newer imaging methods. Manufacturers should be encouraged to listen both to imagers and clinicians to determine new directions, rather than installing technology looking for clinical application in service departments.

Ultrasound

P. N. T. Wells
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Ultrasound can be used to measure several of the physical properties of tissues, from which information relating to structure and function may be derived. The speed of propagation can be measured by triangulation, image optimization, transit time or computed tomography, and provides information about linear dimensions, structure location, organ volume and tissue characteristics. Ultrasonic tissue characterization is no longer believed to be a realistic approach to telehistology; the emphasis is now on differential diagnosis and monitoring temporal changes. Attenuation can be measured by echo amplitude and frequency decrements, transit loss, computed tomography or reflex imaging and is used mainly for tissue characterization. In principle, acoustic impedance can be estimated from each amplitude, but the model depends on parallel layers of tissue and is generally unrealistic. Scattering characteristics can be measured from the frequency and angular dependences of echo amplitude, but care needs to be taken to recognize systematic measurement errors; the information relates to tissue characterization. There is now some interest in measuring tissue propagation non-linearity, but as yet no clinical application has become popular. Motion can be measured by pulse-echo M-mode, real-time imaging, Doppler techniques, fading rate or speckle spatial correlation. Information about motion relates to the speed of structure movement, blood flow velocity, vascular impedance, blood flow velocity profile, flow volume rate, flow disturbance and tissue perfusion. Thus quantitative ultrasonic imaging is already in widespread routine clinical use and there is enormous scope for further development.

Quantitative digital angiography

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Extraction of quantitative angiographic information from digital fluorographic images requires accurate assessment of system performance. A scheme has been devised which uses digital information to extract quantitative measurements of noise, contrast and resolution from simple test objects. Quantitative information on blood vessel location, lumen area, lumen shape and blood flow requires accurate knowledge of the vascular anatomy in three dimensions. Schemes for deriving this information from two or more radiographic views are reviewed. Schemes include digital tomosynthesis using modified back projection algorithms. Alternatively reconstruction, from a pair of radiographic angiograms, follows user-identified correspondence with the aid of the epipolar constraint and the use of knowledge based matching from a stereo pair of radiographic views. Reconstruction using orthogonal views achieves the highest reconstruction accuracy, provided X-ray gantry position can be accurately recorded. Lumen area measurement, shape assessments and blood flow analysis require accurate densitometric calibration. Our system using a pair of scanning slits is presented as a means of removing the effects of scatter, veiling glare and beam hardening. Phantom work shows that densitometric errors can be reduced from a factor of about two to less than 5%. In the research laboratory reconstruction of blood vessel position accurate to better than 1 mm, lumen area measurements accurate to 0.5 mm^2, changes of lumen dimensions of 0.1 mm and instantaneous blood flow estimates accurate to 10% have been achieved. Introduction of these techniques into routine clinical practice requires access to powerful computational facilities, further algorithmic development and particular attention to appropriate user interfaces, as well as assessment of the role of these techniques in medical research and clinical practice.

Quantitative imaging in magnetic resonance

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Although conventional magnetic resonance (MR) images are not intrinsically quantitative, being highly dependent on sequence parameters, physical composition, and instrumental factors; many quantitative measures can be derived from MR data. These include anatomical measurements, such as lesion volume; CSF space; and the volume of neural structures, which may be related to neurological function. With moving structures, real time imaging or gated studies permit cardiac volume measurements, such as end diastolic and systolic volume. Physical properties of the tissue: proton density, T_1 and T_2 relaxation times may be measured absolutely, facilitating differential diagnosis, allowing multiple sclerosis plaques to be identified, and tumour to be discriminated from fibrosis. Often tissue characterization by statistical texture analysis can be of assistance. Absolute image parameters permit changes with therapy to be followed. In some tissues, multi-component analysis is required, for instance in the marrow where two different tissue types (haemopoetic tissue and lipid) are closely mixed, or in the brain, where T_2 measurements may discriminate intra- and extracellular fluid. Exogenous agents, such as Gd-DTPA, may be used to define active tumour volume, and in concert with quantitative and dynamic studies, may be used for blood–brain barrier permeability measurements. Further developments in contrast agents with improved specificity for particular tissues are likely, leading to an increasing role in functional studies. Fluorine labelled agents may be of value in some applications. Diffusion may be measured by MRI, and may be helpful in identifying fluid compartments and in studying effects causing changes in cellular dimensions. Perfusion is less readily measured because of the low sensitivity and the difficulties in separating bulk tissue motion from perfusion. Exogenous agents may be required for accurate measurements. Flow can be measured by using its inherent natural contrast, and phase sensitive images can be used to quantify major vessel flow. Metabolite measurements provide a major strength of MR, with imaging proving possible where high concentrations are present, or suitable localization methods being used for specific tissues and lesions. Cellular energetics and agents linked to cellular growth can be monitored with 31-P spectroscopy; N acetyl aspartate, a neural marker, lactate and lipid can be monitored with proton spectroscopy, and 13-C spectroscopy is also practicable. Sodium imaging provides a means of monitoring the sodium pool and fluorine labelled therapeutic agents can be followed. Future developments are likely to include improvements in pulse sequences, and in hardware, particularly for real time measurements. Considerable advances are likely in flow and metabolite measurements, and in more specific contrast agents.

Quantitative imaging in computed tomography

K. Faulkner
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Computed tomography (CT) scanners produce cross-sectional images with excellent anatomical accuracy and good contrast descrimination. The pixel value at a position in an image is related to the linear attenuation coefficient of the material in the corresponding position in the object. Small changes in contrast can be seen in a CT scan because CT scanners can accurately deduce the linear attentuation coefficient at a point. The accurate positional information contained in CT images can be used quantitatively for distance measurements, for example in stereotaxis. Ever since the introduction of CT scanners, studies have been undertaken in attempts to use the linear attenuation coefficient information for quantitative purposes. Initially, clinical studies were performed to correlate pixel numbers with chemical composition, for example iron content in haemochromatosis. However, pixel values tend not to be reproducible, as a number of patient and equipment related factors will affect this quantitative information. Manufacturers have managed to solve some of the problems of reproducibility associated with the equipment. A range of quantitative CT options for bone mineral assessment and xenon studies are now provided by CT manufacturers. The impact of these recent technological innovations on quantitative CT and prospects for future developments are reviewed.

Textural analysis in quantitative magnetic resonance imaging of metabolic bone disease

X. P. Zhu, R. W. Whitehouse, J. E. Adams, I. Isherwood, J. P. R. Jenkins and *P. H. Adams
*Departments of Diagnostic Radiology and *Medicine, University of Manchester*

Textural analysis techniques have been applied to quantitative spinal MRI data sets in patients with a variety of metabolic bone diseases. Twenty-six patients were selected for study on the basis of clinical diagnosis and vertebral trabecular bone mineral density as measured by quantitative computed tomography. Three patient groups were defined: those with primary hyperparathyroidism and a normal trabecular bone mass for age (eight patients), osteoporosis (10 patients) and osteomalacia (five patients with familial vitamin D resistant and three with acquired disease). Textural analysis was performed on the T_1 tissue maps of sagittal lumbar MRI scans using three different detection methods. These measurements were then subjected to Karhunen–Loeve transformation for feature analysis. This formed the basis for subsequent disease classification. T_1 data obtained from the Regions of Interest showed no statistical separation of the groups. Textural analysis demonstrated highly significant separation of (a) the osteoporotic from the osteomalacic group ($p < 0.001$), (b) the primary hyperparathyroid group and those with either osteoporosis or osteomalacia ($p < 0.005$–0.002). The two subgroups of osteomalacia could also be clearly identified. There was correlation ($r = 0.52$) between bone mineral content and textural parameters in the primary hyperparathyroid and osteoporotic groups. These results indicate that textural analysis of MR tissue maps can provide tissue discrimination in some forms of metabolic bone disease. Additional patients are presently being introduced into the training set to assess the diagnostic predictive value of the technique. Preliminary results are encouraging.

Quantitative computed tomography for vertebral trabecular fat estimation

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*Departments of Diagnostic Radiology and *Medicine, University of Manchester*

Single energy QCT (SE QCT) is used to measure bone mineral density. The technique may however underestimate the mineral content of vertebral trabecular bone owing to its fat content. Dual energy QCT (DE QCT) can correct this but gives poorer precision. The difference between SE QCT and DE QCT is therefore related to the marrow fat content. To evaluate the practical usefulness of this measure of marrow fat, a retrospective analysis of the results of SE QCT and DE QCT in 295 women has been performed. All patients were scanned on a GE 9800 general purpose CT scanner using a fluid calibration phantom containing K_2HPO_4 solutions. Patients with primary hyperparathyroidism (143) and endometriosis (26) were considered likely to have a normal vertebral marrow fat content. The pooled data from these patients showed an age-related increase in DE BMD–SE BMD, reflecting an increasing marrow fat content with age, but with a wide dispersion around the regression line. The influence of steroids on marrow composition was assessed in patients with Cushing's syndrome (17) and on long term oral steroid treatment for asthma (9). In these patients, the mean DE BMD–SE BMD was significantly elevated ($p < 0.05$), suggesting an increase in marrow fat content. Patients with osteomalacia (13) and breast carcinoma (9) showed a mean decrease in DE BMD–SE BMD ($p < 0.05$), indicating less fat than expected for age, presumably as a result of excess unmineralized osteoid in the former and marrow replacement with metastatic disease in the latter. The remaining 78 patients had osteoporosis with a DE BMD–SE BMD within the control range.

Clinical and experimental evaluation of a method for iodine quantitation using digital fluorography

J. P. Owen, C. J. Kotre, W. Thompson, K. Faulkner and R. M. Harrison
Department of Radiology and Medical Physics, University of Newcastle upon Tyne

It has long been desired to enhance the role of conventional radiological techniques by offering functional as well as anatomical information. Digital fluorography has already approached this ideal through parametric imaging and time–density quantitation of contrast media kinetics, but both methods offer only relative indices of organ function. Absolute measures of organ function from such studies requires the ability to quantify iodine accurately in the fluorographic images. A technique is described for the *in vivo* determination of tissue iodine by digital fluorography. Experimental studies indicate that the method is capable of measuring iodine concentrations of $20\,\mathrm{mg\,cm^{-2}}$ in digital fluorograms to an accuracy of $1.4\,\mathrm{mg\,cm^{-2}}$ with a repeatability of $0.3\,\mathrm{mg\,cm^{-2}}$ from regions as small as 5 mm. The results of clinical studies of renal iodine excretion in patients using this method are presented.

Cerebral vascular reserve in acute ischaemic stroke

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Studies using positron emission tomography have shown that the most sensitive indicator of cerebral vascular reserve (CVR) is the ratio of cerebral blood flow to blood volume which is the reciprocal of median cortical transit time (MCTT). We have serially evaluated CVR, using a new method of quantifying MCTT following intravenous injection of sodium pertechnetate, in 23 patients presenting with acute first ever ischaemic cerebral infarction, in addition to CT scanning and extra- and transcranial Doppler sonography. All patients presenting with a clinical diagnosis of total anterior circulation infarction (secondary to internal carotid or middle cerebral artery occlusion) were found to have significant impairment of CVR and recanalization of the middle cerebral was associated with restoration of CVR symmetry. The majority of patients presenting with partial anterior circulation infarction (presumed secondary to a distal branch occlusion of the middle cerebral artery) showed no significant CVR abnormality as did three patients with lacunar infarction (secondary to disease of the small deep penetrating arteries). Median cortical transit time is relatively cheap and simple to perform and our preliminary results suggest that it may be of considerable value in the evaluation of patients with acute cerebral infarction and particularly in the monitoring of those with strokes secondary to major vessel occlusion.

Photodynamic therapy

Abstracts of papers presented at a meeting of the BIR at 36 Portland Place, London W1N 4AT, on Wednesday, 4 April 1990

Chairman: Dr Ash

Biochemistry of photodynamic therapy, by S. Brown
Suitable lasers for photodynamic therapy, by J. Colles. Abstract not received
Physics of superficial photodynamic therapy, by A. Mackenzie
Physics of interstitial photodynamic therapy, by J. P. A. Marijnissen and W. Star
Photodynamic therapy in animal tumour systems, by S. G. Bown
Clinical experience with superficial photodynamic therapy, by J. Garruth
Clinical and experimental studies in interstitial photodynamic therapy, by C. Lowdell

Biochemistry of photodynamic therapy

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Photodynamic therapy is a technique whereby light (usually from a laser) and a photosensitizing drug are used in combination to achieve a therapeutic effect. Under the conditions used, when either the drug or the light are applied separately, there is no biological damage. The drug acts as a "photocatalyst", since it absorbs the energy from light, passes it on to molecular oxygen which thereby becomes activated, and is then regenerated as the normal photosensitizer. Efficient light absorption by the drug is therefore essential for a photodynamic effect. The drug which has been used up to the present time in clinical photodynamic therapy is prepared from haematoporphyrin derivative, which is a complex mixture of polymerized, aggregated and monomeric porphyrins. In this mixture, the aggregated or polymerized fraction is therapeutically useful, since it is able to concentrate in tumours, whereas the monomeric fraction either does not enter tumours or is rapidly removed. Photofrin II and polyhaematoporphyrin (the latter used in our laboratory) are preparations which are enriched in these tumour localizing fractions. From the biochemical viewpoint the major areas of research include the pharmacokinetic behaviour of the drug in patients and experimental animals, the mechanism of localization of the drug in tissues, especially tumours, the mechanisms by which the photoprocess is able to destroy cells and tissues and the development of new drugs. All of these area are under study in our laboratory.

Acknowledgment

We wish to thank the Yorkshire Cancer Research Campaign for financial support.

Physics of superficial photodynamic therapy

Alan L. McKenzie
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In clinical practice, the physics of superficial photodynamic therapy is very straightforward: a measure of the light exposure to the treatment area is found by dividing the applied power by the area to be treated and multiplying by the treatment time. A more appropriate quantity is radiant fluence (time-integrated "space irradiance"). The depth dependence of fluence beneath the surface of illuminated tissue can show a peak rising to as much as nine times the incident exposure. Essentially, this arises as the concentration of photons which have penetrated the tissue surface builds up because of the "bottleneck" of scatters within the tissue. The detailed dependence is a function of the scattering and absorption characteristics of the tissue, and work is in hand to measure these quantities non-invasively during treatment. The threshold fluence for tumour necrosis also depends upon the photosensitizer concentration, and experience shows that, at 5 mg/kg HPD or 2 mg/kg "Photofrin II", no necrosis is produced below an incident exposure 'of around 25 J cm^{-2}. Photosensitizers are gradually "photobleached" over long periods of exposure to light, with the result that, for example, the combination of 50 J cm^{-2} of incident light and 5 mg/kg HPD will produce a deeper necrotic lesion than 100 J cm^{-2} and 2.5 mg/kg. Photobleaching may also account for the observation that, in patients who have lost photosensitivity on the face several weeks after treatment, the unexposed skin, for example on the trunk, may retain photosensitivity to test doses of light for many months. This means that patients who believe themselves no longer vulnerable to sunlight nevertheless should be counselled about sunbathing after treatment. Laser photodynamic therapy, like radiotherapy, is a field in which physics is one of several disciplines which combine synergistically into a powerful weapon in the cancer war.

Physics of interstitial photodynamic therapy

J. P. A. Marijnissen and W. M. Star
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The physics of interstitial photodynamic therapy (PDT) involves light delivery, light dosimetry and thermometry. Interstitial PDT is used to overcome poor light penetration into tissues and to enable effective and selective treatment of non-superficial or even bulky tumours. Here, selective tumour destruction does not primarily result from selective retention of a photosensitizer, but from limiting the irradiated volume. In interstitial PDT light is delivered by optical fibres. Therefore a laser is needed and a beam splitter to direct light to a number of fibres simultaneously. Fibres with tips that emit light more or less uniformly along an "active length" $\geqslant 1$ cm are commercially available, but can also very easily be home made. A convenient technique is surgical implantation of flexible translucent tubing and "afterloading" of the fibres, like in interstitial radiotherapy using irridium. Light dose prescription is still rather primitive in practice. Analogous to mg hours used formerly in interstitial radiotherapy, in interstitial PDT the light dose is expressed in Joules per cm of light emitting fibre. A better method is treatment planning using measured "optical isodoses". Simple models have been developed to compute light distributions for interstitial PDT, which agree reasonably well with measurements. These models do not consider inhomogeneous optical properties of tumours or changes in these properties during interstitial PDT, which have been observed in animal and human studies. Other problems are light absorption by, and photobleaching of, the photosensitizer. Understanding and optimization of interstitial PDT therefore require light dosimetry *in vivo* during treatment using isotropic probes. If hyperthermia is to be avoided in interstitial PDT, power levels must be kept low and treatment times become unacceptably long. The power levels used in practice often lead to hyperthermia, which is taken for granted. The synergistic effect of interstitial PDT and simultaneous light-induced hyperthermia may be better exploited by measuring the temperature *in vivo* and keeping it at an optimal value by varying the laser power.

Photodynamic therapy in animal tumour systems

S. G. Bown
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Most animal studies of photodynamic therapy (PDT) have looked at tumours implanted in experimentally convenient sites (*e.g.* subcutaneously in the flank). It is well established that PDT can cause tumour necrosis in this situation, but the key to developing clinical applications is to know what happens to tumours (and the adjacent normal tissue) when they are growing in their organ of origin. Outside the brain, there is seldom more than 2–3 times as much sensitizer in tumour as in the adjacent areas, and it is not practical to destroy tumour where it meets normal tissue without damage to the normal as well. However, the nature of PDT necrosis in many normal thin-walled organs (colon, bladder, trachea) is such that even with full thickness necrosis, there is no loss of mechanical strength at any stage because of a lack of damage to collagen) and healing is by regeneration. As long as this collagen "scaffold" is present across tumour areas, necrosis here can heal safely as well, and this has been shown in rat colon cancers penetrating to the serosa. The extent of PDT necrosis in any tissue depends on the light dose and the tissue concentration of photosensitizer, but it is difficult to get necrosis extending more than a few mm, which makes PDT most suitable for treating very small tumours or as an adjunct to another method (*e.g.* surgery) for removing the main tumour bulk.

Clinical experience with superficial photodynamic therapy

J. A. Carruth
Royal South Hampshire Hospital, Southampton

Photodynamic therapy is a new and exciting treatment modality which offers considerable promise in the management of many forms of malignant disease. The technique is based on giving a patient with a malignant tumour a photosensitive substance which is either selectively absorbed by, or retained by, malignant tissues giving, after a period of time, a high tumour/normal tissue ratio. The intra-tumour photosensitizer is then photoactivated by an appropriate wavelength of light, usually produced by a laser, causing the release of toxic substances which destroy the tumour while sparing the surrounding tissues. The ideal situation remains some way off, but there is an enormous amount of research in progress into all aspects of this treatment technique and it is to be hoped that it will achieve its full potential in the future. To date, the only drug/light combination which has been used clinically is that of haematoporphyrin derivative and red light at a wavelength of 630 nanometres produced by a dye or gold vapour laser. The technique is without side-effects, apart from the retention of prophyrin in the skin giving rise to a prolonged cutaneous photosensitization for a period of up to 6 weeks after the injection. A trial of this technique for tumours of the skin and head and neck has been carried out in Southampton since 1983 and 40 patients have been treated. Tumours of the skin included single and multiple basal cell carcinomas, the carcinoma *in situ* of Bowen's disease and metastatic chest wall disease from carcinoma of the breast. Local control was achieved in a number of patients with recurrent adenoid cystic carcinoma of the maxilla and with post-nasal carcinoma. Control with post-nasal carcinoma appears to be most exciting, as once radiotherapy has failed there is no other curative treatment. Head and neck tumours appear to be ideal for this form of therapy as they are localized and accessible, metastasize late and surgery is mutilating either to the appearance of the patient or to his ability to talk and swallow. When new drugs/light combinations are available it is to be hoped that photodynamic therapy will achieve its full potential.

Clinical and experimental studies in interstitial photodynamic therapy

C. P. Lowdell
University Department of Radiotherapy, Cookridge Hospital, Leeds

Interstitial photodynamic therapy (PDT) has been studied in an experimental animal tumour system and in patient treatments. Interstitial therapy should overcome the problems of poor light penetration and the high incidence of skin necrosis seen with superficial PDT. In the animal studies, measurements of light intensity at the skin surface during treatment has determined the relative efficiency of plane cut fibres and diffusing fibres with respect to fibre output power thresholds for thermal effects. These, together with intra-tumour temperature measurements, showed that a power output below 150 mW is desirable for interstitial PDT, and that diffusing fibres are the fibres of choice. Light dose responses demonstrate a threshold effect for PDT between 50 and 100 J and a linear response to escalating light dose. In this tumour system one fibre proved superior to two fibres (6 mm separation) for equivalent light doses in a range of 100–800 J. Interstitial PDT was superior to superficial PDT both in terms of growth delay and morbidity in relation to skin necrosis. Forty-two cutaneous and subcutaneous tumours in eight patients have now been treated using diffusing fibres and polyhaematoporphyrin (PHP) with red light (630 nm). Single fibres have been used to treat nodules of 0.1–2 cm^3, and volume implants using 2–8 fibres with separations between 8 and 12 mm to treat tumours of 1.7–60 cm^3. A complete response rate of 55% has been obtained increasing to 71% at 2 mg/kg of PHP. The incidence of skin necrosis is lower than with superficial therapy, but as yet our complete response rate is lower than that achieved with superficial PDT for comparable tumours. When responses to superficial therapy are compared directly with interstitial, it seems that complete responses occur at lower equivalent light doses with the former. *In vivo* measurements of optical interaction coefficients have demonstrated that in human tumour tissue the penetration depth of 630 nm light is 4 mm. Values for reduced scattering and absorption coefficients have also been derived and a light dose response demonstrated for these treated tumours.

1990, *The British Journal of Radiology*, *63*, 671–672

Book reviews

Something about X-rays for Everybody. By Edward Trevert, pp. ii + 82, 1988 (Medical Physics Publishing Corporation, Madison, USA), £12.
ISBN 0–944838–05–7

This delightful little book is a facsimile reproduction of one published in June, 1896. It consists of extensive quotations from American electrical journals of the day linked as a continuous text under the chapter headings: "The intensity coil and the crookes tube", "Experiments with X-rays" and "The fluorscope and other apparatus". Radiology managers who are suffering from cuts in their departmental budgets will be pleased to know that with the aid of detailed instructions given in Chapter One they will be able to construct an induction coil from inexpensive materials. The tube itself will be more difficult, as I doubt that a modern "incandescent lamp with its filament broken" would perform well even with the suggested modifications.

We are assured that with proper care and the necessary apparatus, even an amateur may meet with wonderful success. Similar assurances probably accounted for a few radiation burns in the prioneer years. Figure 40 shows the fluorscope being used to test the operation of an X-ray tube, the test object being the operator's hand. This procedure was responsible for many of the occupational skin cancers causing pain, disfigurement and in some cases death amongst pioneer radiographers and radiologists.

Not all of the line drawings have reproduced well; I doubt if the original 1896 radiographs, however, were of much better quality than these. Figure 31 purports to show a bone tumour, and on the basis of this radiograph, the patient's arm was amputated. One hopes that the clinical evidence was more convincing than the image. In America, as in England at this time, many X-rays were made by non-medical operators, sometimes in the factories producing the apparatus. Patient co-operation was essential when exposure times were up to 25 min.

The book is similar in format, though less technical, to some published in England before 1900, for example Bottone's *Radiography* which can be consulted in the BJR library. I am not aware that Trevert's book was available on this side of the Atlantic before the present reprinting. It was intended for the general reader with an interest in electrical experiments, but the practical instructions would have made it equally suitable for the first attempts at medical radiology which were made in Britain as well as the USA in the first few months after Roentgen's discovery.

Readers with an interest in the history of their own subject will enjoy reading and owning a copy of this book. The price, page for page, is what one would expect for a modern radiological textbook; the original cost was 50 cents.

JEAN GUY

Guidance on Radiation Received in Space Activities. NCRP Report No. 98. National Council on Radiation Protection and Measurements, pp. x + 227, 1989 (NCRP Publications, Maryland, USA), $17.00.
ISBN 0–929600–04–5

The guidelines currently used by the National Aeronautics and Space Administration (NASA) for radiation exposure to astronauts are based on 1970 recommendations. The philosophy was that radiation risks should be kept in perspective in the context of other risks of spaceflight. Since that time, the population of astronauts has increased and now includes women, the age distribution has changed towards younger groups, radiation risks themselves have changed, and the ALARA principle has been established. These changes prompted this revision of the guidance for space activities which has been produced by the NCRP.

Clearly, few readers of this journal will have direct involvement with space research, but the book is worth browsing through just the same, because the approach of the report is essentially a model for any assessment of radiation risk to a well defined population, such as radiation workers in a clinical environment.

After two brief chapters setting the context of the report, the reader is introduced to the different types of radiation encountered in space: the Earth's radiation belt containing electrons and protons, galactic cosmic rays which include heavier ions and streams of charged particles which reach the earth minutes or hours after a solar flare. It comes as a surprise to learn that orbiting astronauts can easily accumulate doses in the order of 1 mSv daily, and that, on a mission to Mars, they could expect to receive 1 Sv — and that is without the added hazard of radiation from a solar flare.

In subsequent chapters, the biological effects of space radiations are considered: electrons, protons, neutrons and high-Z, high-energy (HZE) particles encountered in deeper space. The effects of HZE particles, in particular, are interesting. For instance, the light flashes reported by Apollo astronauts on lunar missions are probably a result of the depolarization and firing of photoreceptors in the retina. The more sinister corollary is that HZE particles may cause microlesions, for example in crucial areas in the brain or fovea. The jury is still out on the question of whether such lesions are, indeed, produced. There is also more conventional discussion of radiation carcinogenesis, genetic risks and non-stochastic effects.

The report concludes with a discussion of radiation protection standards in space, and recommends a career radiation risk limit (for fatal cancer) of 3% for all ages and both sexes. Thus, for example, a 25-year-old woman would be limited to a career whole-body dose equivalent of 1 Sv. Unfortunately, the report does not appear to have taken into account the revised dosimetry, DS86, and so the conclusions and recommendations will presumably have to be revised eventually.

The book is unlikely to be on the required reading list of many British scientists and doctors, but that is an indictment of our own poor record in the European space effort rather than of the book itself. As a model for the analysis of a radiation environment, and for background knowledge which may have wider application than the title would suggest (e.g. dosimetry on Concorde?), I am pleased to recommend the book.

ALAN L. MCKENZIE

Quality Assurance in Radiotherapy. Institute of Radiation Hygiene and World Health Organization, pp. viii + 52, 1988 (World Health Organization, Geneva), SFr11.00.
ISBN 92–4–154224–1

This short book is the result of an international workshop, organized jointly by the Institute of Radiation Hygiene and the World Health Organization, held in the Federal Republic of Germany in December 1984. It defines quality assurance in radiotherapy as "all those procedures that ensure consistency of the medical prescription and the safe fulfilment of that prescription as regards dose to the target volume, together with minimal dose to normal tissue, minimal exposure of personnel, and adequate patient monitoring aimed at determining the end result of treatment."

The book is divided into three major sections. These are operational aspects, physical and technical aspects and clinical aspects. It summarizes the factors to be considered in establishing a programme of quality assurance at both local and national levels. The physical and technical checks needed to verify frequency and tolerance levels are tabulated.

The clinical aspects of quality assurance are described with the aim of ensuring the best possible patient management. It provides a short but useful list of references and a bibliography.

This is a well produced book which will be invaluable to radiotherapists, radiographers and especially medical physicists.

Quality assurance in radiotherapy is an essential requirement, but unfortunately the subject has often taken second place to other more exciting but less demanding subjects. This book will help to put radiotherapy quality assurance in perspective.

At about £4.00 it is good value for money!

COLIN H. JONES

Radiation Protection Theory and Practice. Proceedings of the 25th Anniversary Symposium of the Society for Radiological Protection. Ed. by E. P. Goldfinch, pp xxiv + 488, 1989 (IOP Publishing, Bristol), £55.00.

ISBN 0–85498–0520

This is a compilation of the abstracts of 112 papers given at the 4th International Symposium organized in Malvern by the Society for Radiological Protection in June 1989, so publication is commendably rapid. Each abstract is given at least four pages, so there is room for much information; they are published as submitted, so the typefaces and style are very variable.

The aspects covered include the radiation risks, protection, accidents and emergencies, dosimetry, environmental exposures, biology and public relations. This is no text book of radiation protection for the beginner but provides a review of the areas where progress is being made in this rapidly developing subject. In particular, the changing perception of the magnitude of the risks of radiation is well reviewed, together with the viewpoint of the International Commission on Radiological Protection. Other hazards besides ionizing radiation are reviewed, for instance, the magnetic fields from power lines, and microwave exposure guidelines are discussed. The large section on accidents and emergencies reflect the experience of Chernobyl and Goiânia.

The book can be read by all interested in radiation protection. Those who have a knowledge of the subject and who want to know of the current areas of interest will get most out of it.

J. G. B. RUSSELL

Medical X-ray, Electron Beam and Gamma-ray Protection for Energies up to 50 MeV (Equipment Design, Performance and Use), NCRP Report No. 102. National Council on Radiation Protection and Measurements, pp. viii + 139 1989 (NCRP, Maryland, USA) $17.00.

ISBN 0–92600–03–7

This report is necessarily very brief, for its aim is to cover the radiation protection requirements of medical radiation generators of all descriptions — except heavy particles — including design, performance and use. The result is that diagnostic equipment is covered in 45 pages while less than half that space is allocated to therapy equipment. The remainder of the text deals with general aspects of radiation protection and the promotion of the NCRP. The preface confesses to "considerable duplication of recommendations in the report" particularly in the diagnostic section to avoid "the need to keep referring back to the basic recommendations . . ." The reader is constantly referred to other supporting texts including 21 other NCRP reports.

As an overview of the subject, the text makes comprehensive easy reading and provides sufficient information for the reader to know where to go for more detailed information in any one of the particular areas covered. The reader is constantly reminded that the report is of national rather than international origin and should therefore check the advice against his local requirements. For example, paragraph 5.2.3 relates to X-ray therapy equipment operating above 500 kV and sub-paragrapnh 3(d) requires that "Persons other than the patient *shall not* be present in the treatment room when radiation of energy greater than 500 keV is being used", and paragraph 5.2.2 on X-ray therapy equipment operating below 500 kV and sub-paragraph 3(d) states, "Persons other than the patient *shall not* be present in the treatment room when radiation of energy greater than 150 keV is being used", whereas ICRP Report 33 (1982, paragraph 138) recommends, "For treatment at tube voltages of not more than 50 kV, it is permissible for the operator and other essential persons to remain in the room". This is alas only one of several areas where the advice given appears to be at variance with internationally accepted recommendations.

In the light of quotations such as these, it is interesting to note that the Glossary (sometimes referred to as Appendix A) defines "kilovolt (kV)" but does not define keV. This rather free use of terminology is also seen in the diagnostic section where we have both "source to film distance (SFD)" and "target–film distance", neither of which is in need of definition, although the Glossary does define "source-to-image-distance (SID)" and "source–surface distance (SSD)".

On the whole, this Report is disappointing and may therefore only prove to be a valuable reference for those practising radiation protection within the area covered by this legislation. If the contents are eventually found to be in line with the revision of the ICRP recommendations now in progress, then the value of Report 102 will take on a new dimension.

C. K. BOMFORD

BIR Bulletin

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Please address all correspondence to: Honorary Editor, BIR Bulletin, The British Institute of Radiology,
36 Portland Place, London W1N 4AT
The British Institute of Radiology is not responsible for opinions expressed in the BIR Bulletin

Library Now Fully Manned

The British Radiological Library is now lucky enough to have two librarians: Gunnel Ingham, who has performed wonders holding together the library and its services to members on a part time basis (14 hours a week), and now Stephen Johnson, who will share the workload of running the library, extend manned library opening hours to 40 hours a week and introduce library automation.

Computer technology will provide more efficient access to library stock and allow the library to link into wider information networks via Online searching and CD ROM. This will allow rapid response to members' requests for information. It will also allow the library to establish its position fully as the leading source of information on radiology in the UK.

We are currently examining hardware/software packages which would suit our requirements. The progress of the automation project will feature in subsequent issues of the BIR Bulletin.

STEPHEN JOHNSON
SYSTEMS LIBRARIAN

Moves Afoot at the BIR – Continued

Repair and restoration of the ceiling in the du Boulay Member's room is completed and further refurbishment is continuing.

The repair and restoration of the Library ceiling has been completed. Apologies are extended to all members who have used the library recently as access has been disrupted. A full service will be restored by mid-August.

The General Secretary's Office and Conference Office have now relocated to the former BMUS Office and Siemens Room on the second floor.

The Administration Office has now moved into the former Conference Office (Jan Lewando Room) thus freeing the front office for use as the new Siemens Room. This room is being used as a meeting room and will be refurbished shortly.

Pat Lacey, Darren Weeks and Marvin Booth of Clark & Fenn at work on the Library ceiling

Eddie Moloney, the foreman

Work installing a reception desk and moving the glass security doors forward has now begun.

We hope that all of the above works will be completed by the end of September 1990.

The administration extends its apologies to all members for any inconvenience experienced during these works.

Library News

The BIR Library is open weekdays 9 a.m.–5 p.m. (7 p.m. on Tuesdays and Thursdays).

The journal stock includes more than 100 titles. Although journals may not be taken out of the library, there is a photocopy service, also available by post or FAX. A list of current journals is available on request and is also published in the March and September issues of the Bulletin. Most books (except the historical collection) are available on loan.

Members can apply to the BIR librarian for a visitor's card which allows limited use of the RSM library for reference purposes, including photocopying and searches.

Recent additions to the library

KARZMARK, C. J. & MORTON, R. J., 1989. A primer on theory and operation of linear accelerators in radiation therapy.

NATIONAL CANCER INSTITUTE (USA), 1990. Monograph 10. The lymphomas, current concepts in pathogenesis and management.

TREVERT, E., 1988 (original copyright 1896). Something about X-rays for everybody.

BIR Calendar

Current Progress in Magnetic Resonance: Scientific and Clinical Developments in the UK
October 15, 1990
Middlesex Hospital
Organizer: B. S. Worthington

Cracking Gallbladder and Bile Duct Problems
October 18, 1990
All day meeting
Chairmen: R. H. Dowling and R. Dick
Organizer: A. Adam, London
Speakers: R. H. Dowling, C. Russell, P. R. Mueller, W. R. Lees, D. Martin, R. Dick, I. S. Benjamin and A. Adam

Prediction and Management of Tumour Response to Treatment
November 9, 1990
Organizer: R. Camplejohn

IPSM/Nuclear Medicine Radionuclide Tomography Update
November 21, 1990
All day meeting organized by IPSM

Planning for 1992 — A Review of Radiation Protection Practice in Member States of the EEC
December 5, 1990
Institution of Electrical Engineers
Organizer: M. Fitzgerald

Is your Mammography up to Scratch?
January 17, 1991
Scientific Societies Lecture Theatre
Joint BIR/RCR/RSM all day meeting
Organizer: G. H. Whitehouse

Cerebral Bloodflow Practical Measurement and Clinical Relevance — a Multimodality Approach
February 12, 1991
All day Meeting
Organizer: A. Smith

CT — Are the Bells and Whistles Worthwhile?
February 20, 1991
All day meeting
Organizers: A. Dixon and S. Golding

Radiobiology Proffered Papers
February 22, 1991
Organizer: R. Camplejohn

Radiation Oncology/IPSM
April 10, 1991
All day meeting organized by IPSM

RADIOLOGY 91 and MED X RAY
Date to be announced
Brighton

Radiation Oncology and Radiobiology: Particle Therapy
June 7, 1991

The New Legislation — Friend or Foe (After the White Paper ... and into Europe)
June 13, 1991
All day meeting orginized by the Industry Committee
Chairmen: C. A. Joslin, O. Craig and D. Rigg
Speakers include J. Roylance, I. Watt, E. Sutherland, I. Isherwood and P. Richardson

Conversazione
June 27, 1991
Painter's Hall, London
Lecture: " Half an Eye on the Sty", by Sir Stephen Furness.

Unless otherwise indicated, enquiries about the following events should be addressed to the Conference Manager, British Institute of Radiology, 36 Portland Place, London W1N 4AT (Tel. 071-580 4085).

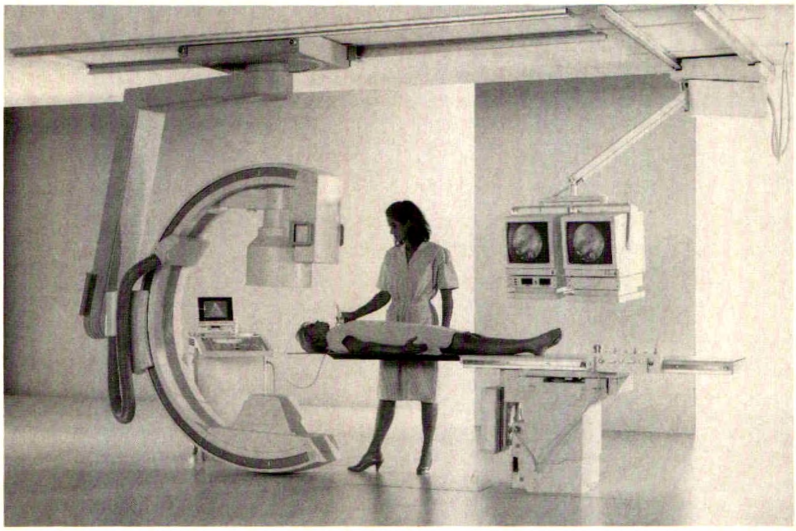
BIR T-shirts and Ties

BIR T-shirts are available to members at £6.50 each (including postage) and are black or navy blue with a white skeleton on the front and back (see picture). BIR ties are £6 each (including postage). They are navy blue or maroon red and carry the rays from the Institute's logo, in gold. Please send a cheque payable to the BIR with the order.

Claire Brice and Charlotte Mcleish wearing BIR T-shirts

Product News

Philips Integris C2000 System



The receipt of the first order for a Philips Integris C2000 System for New Cross Hospital, Wolverhampton, marks the beginning of a new era in equipment specially designed for a completely digital approach to diagnostic radiology.

The increasing demand placed on special procedures rooms, to have the capability of undertaking both complex vascular procedures and the increasing range of interventional techniques, has led Philips to develop and introduce the Integris C2000 System.

INTEGRIS C2000 is a new, digital, fully integrated imaging system with a broad range of capabilities, covering diagnostic vascular procedures as well as vascular and non-vascular interventional radiology.

The unique, perfectly-balanced C-arm ensures safe, speedy movements and eliminates the possibility of collision with either patient or operator. The 14" image intensifier, with fibre optics, combines high quality images with compact design, while the depth within the C-arm itself allows the "C" to remain stationary and in correct alignment with the patient-table for all examinations.

All the exposure modes are logically incorporated so that all imaging modalities are always ready and easy to use. The tabletop has been lengthened to function as an instrument trolley, eliminating the need for additional obstructing small tables and trolleys.

This functional system performs such a wide range of specialized tasks that it is predicted to become indispensable to the modern X-ray department.

For further information contact Duncan Thomas, Philips Medical Systems, Kelvin House, 63-75 Glenthorne Road, Hammersmith, London W6 OLJ.

Schering Health Care Launch New Intrathecal Contrast Agent

Schering Health Care have launched ISOVIST (Iotrolan), the first dimeric non-ionic contrast agent for X-ray examinations. It is licensed for intrathecal applications, such as myelography, and for other body-cavity applications such as arthrography and indirect lymphography.

Owing to its novel structure, Isovist is close to isotonicity; it has so far been used in more than 3000 patients, and in contrast quality and tolerance has been found to compare favourably with the monomeric non-ionic contrast media that are currently available.

Isovist is supplied in two ready-to-use concentrations, containing 240 and 30 mgI/ml. Isovist 240 is available as 10 x 10 ml vials and 10 x 20 ml vials. Isovist 300 is available as 10 x 10 ml vials only.

Further information is available from the product licence holders, Schering Health Care Ltd, The Brow, Burgess Hill, Sussex RH15 9NE. Tel: 0444 232323.

Buchler Introduces FACTS: the Flexible Afterloading Cancer Treatment System

Afterloading Buchler facts uses the advantages of small dimension Iridium-192 high activity sources and offers possibilities for new cancer treatment techniques in addition to gynaecological treatments: *e.g.* afterloading/hyperthermia combination therapy, intraluminal, interstitial (breast conserving) and intra-operative brachytherapy. It features the latest available technology such as an Applicator-in-Applicator system,

integrated *in vivo* dosimetry system, Test-Run-Dummy source and a Quality Assurance programme. It has a Channel Multiplier for 12 or 24 channels and is operated by an IBM PC (or compatible). Facts offers the choice of a point source for sharper bending radii or a linear source for interstitial needles.

For further information contact Sabine Adamitz, Buchler GmbH, Harzbutteler Strasse 3, D-3300 Braunschweig, Germany. Tel: 0 53 07 205-0;
Fax: 0 53 07 205-50.

Inventor of MRI Whole Body Scanner Receives Honour

Dr Raymond Damadian, the inventor of the magnetic resonance imaging scanner, has been made a member of the prestigious American Inventor's Hall of Fame.

Dr Damadian visited Newcastle in January to attend the official opening of the Newcastle Nuffield MR Imaging Centre where Britain's first Fonar MRI scanner has been installed. Over 100 patients were scanned in the first month of operation.

For further information telephone 0600 5518.

New Du Pont Processor Tested at Northamptonshire

The new Du Pont CX-130 processor has been tested in the busy X-ray Department of the Northamptonshire General Hospital for the past 18 months, and is the most recent addition to a Modular Daylight System that has processed more than 552,000 films since February 1985.

The hospital serves a population of some 330 000 spread across a wide area of rural and urban communities, so reliability is essential. The Du Pont CXC130 processor satisfies the need in the Department for high throughput and consistent film quality as it is in use 24 hours a day. The electronic temperature readout, dryer percentage, replenishment rates and processor speed are all easily variable to make the CX130 simple and accurate to use, while the specially vented operation improves the working environment. Mr Philip Webster, the District Superintendent Radiographer, said that it is considerably quieter than the competitors, and with infra-red drying, there is less heat given off, all of which makes for a more pleasant working environment.

MR Max Comes to Newcastle Thanks to Charlie Bear

Dr V. McAllister, Daisy Clark and Charlie Bear in front of the 14 ton superconducting magnet that is the heart of the MR MAX PLUS from IGE, one of the most advanced diagnostic magnetic resonance systems in the world. The purchase of the system by Newcastle General Hospital was made possible by the Regional Health Authority and the Charlie Bear appeal, who contributed £250 000.

BIR Company Subscribers

The BIR company subscriber scheme is aimed at all companies who advertise in the BJR or exhibit at the MED X RAY technical exhibition. For a subscription of £250 p.a. for an initial period of 3 years, an attractive package of benefits is offered.

If your company is interested in joining the scheme, please contact Mr Tony Hudson, Administration Manager, British Institute of Radiology, 36 Portland Place, London W1N 4AT. Tel: 071-580 4085. Companies that have enrolled to date are listed below.

Agfa-Gevaert Ltd
27 Great West Road, Brentford, Middlesex TW8 9AX; tel. 081-560 2131. Product Areas 1. Contact Mr G. Mountford, Director.

Amersham International PLC
Lincoln Place, Green End, Aylesbury, Bucks HP20 2TP; tel. 0296-395222. Product areas 4, 5, 6. Contact Mr James McLaughlin, Sales and Marketing Manager.

Bard Ltd
Forest Houe, Brighton Road, Crawley, West Sussex RH 11 9BP; tel. 0293 27888, ext. 2204. Product area 2. Contact Anna Shores, Product Manager.

British Nuclear Fuels plc
Room 525, Hinton House, Risley, Warrington, Cheshire WA3 6AS; tel. 0925-835022. Product areas 8, 11. Contact Dr R. J. Berry, Director of Health and Safety and Environmental Protection.

Bruel & Kjaer (UK) Ltd
92 Uxbridge Road, Harrow, Middlesex, HA3 6BZ; tel. 081-954 2366. Product areas 3, 6. Contatct Mr Dennis Lewis, Sales Manager.

Cardiac Services Ltd
95A Finaghy Road, South Belfast BT10 OBY; tel. 0232-625566. Product areas 1, 3, 4, 5, 6. Contact Mr R J Brown. Managing Director.

Central Electricity Generating Board
15 Newgate Street, London EC1A 7AU; tel. 071-634 6898. Product areas 7, 8. Contact Mr R. V. Brierley, Office Services Manager.

Du Pont (UK) Ltd
Wedgwood Way, Stevenage, Hertfordshire SG1 4QN; tel. 0438 734000. Product areas 1, 3, 4, 5, 6, 7, 9 and 10. Contact Mr E. G. Lovat, Product Manager, Diagnostic Imaging.

E. G. & G. Limited
Vale Road, Windsor, Berkshire SL4 5JP; tel. 0753-855611. Product areas 1, 6, 7, 8,. Contact Miss Susan Holgate, Sales Executive (Therapy).

Elscint (GB) Ltd
Colonial Business Park, Colonial Way, Watford, Herts WD2 4PT; tel. 0865-340900 . Product areas 1, 3, 4. Contact Faith Gorman, Marketing Manager.

E-Z-EM Ltd
1230 High Road, Whetstone, London N20; tel. 081-446 9714. Product areas 1, 2, 8. Contact Mr D. F. Wills, Sales and Marketing Manager.

Fuji Photo Film (UK) Ltd
125 Finchley Road, London NW3 6JH; tel 071-586 9351. Product areas 1, 3. Contact Mr R. G. Brown, Marketing and Administration Manager.

Gammex-RMI Ltd
34 Shakespeare Street, Nottingham NG1 4FQ; tel. 0602 483807. Product areas 1, 3, 4, 5, 6. Contact Miss Eileen Parr, Commercial Manager.

IGE Medical Systems Ltd
352 Buckingham Avenue, Slough, Berks SL1 4ER; tel. 0753-874000. Product areas 1, 2, 3, 4, 5, 6, 8, 9. Contact Jill Mitchell, UK Sales Support.

Kodak Ltd
PO Box 66, Station Road, Hemel Hempstead, Herts HP1 1JU; tel. 0442-61122. Product areas 1. Contact Mr P. E. Blackwell, Manager, Health Sciences Division.

3M UK PLC
3M House, Bracknell, PO Box 1, Berks RG12 1JU; tel. 0344 426726. Product areas 1. Contact Mr Alan Budge, Marketing Manager.

Mallinckrodt Diagnostica (UK) Ltd
11 North Portway Close, Round Spinney, Northampton NN3 4RQ. tel. 0604-46132. Product areas 4, 5. Contact Mr D. G. L. Wood, Business Manager.

Merit Health Systems Ltd
1 Viking Close, Great Gutter Lane, Willerby, North Humberside HU10 6DZ; tel. 0482 652252. Product area 13. Contact Mr W. Blakemore, Director.

Medical XraySupplies Ltd
Unit 12, Kingsbury Industrial Estate, Church Lane, Kingsbury, London NW9 8AU; tel. 081-205 9500. Product areas 1. Contact Mr R. J. Laird, Sales Director/Mr K. Wartnaby, Managing Director.

Mitsubishi Electric UK Ltd
Travellers Lane, Hatfield, Herts AL10 8XB; tel. 07072 78756. Product area 14. Contact T. F. McCloud, Sales and Marketing Manager.

Nuclear Associates
100 Voice Road, Carle Place, New York 11514-1593, USA; tel. 516-741 7614. Product areas 1, 3, 4, 5, 6, 8. Contact Mr H. Glasser, General Manager.

Nucletron Trading Ltd
Nucletron House, Tarporley Business Centre, Tarporley, Cheshire, CW6 9UY; tel: 0829 733611. Product areas 6, 8. Contact Mrs Marilyn A. Hart, Office Manager.

Nycomed (UK) Ltd
Nycomed House, 2111 Coventry Road, Sheldon, Birmingham B26 3EA; tel. 021-742 2444. Product areas 1, 3. Contact Mr L. Birch Hansen, Managing Director.

Oxford Magnet Technology
Wharf Road, Eynsham, Oxford; tel. 0865 880880. Product area 1. Contact Pauline Hobday, Director of Sales and Marketing.

Philips Medical Systems
Kelvin House, 63–75 Glenthorne Road, Hammersmith, London W6 OLJ; tel. 081-741 1666. Product areas 1, 3–8. Contact J. M. Woolston, Sales and Marketing Manager.

Polaroid (UK) Ltd
Ashley Road, St Albans, Herts AL1 5PR; tel. 0727 59191. Product areas 1, 3. Contact Ms Tina Thompstone, Product Supervisor.

Premise Engineering Ltd
Tibbs Hill Road, Abbots Langley, Watford, Herts WD5 ODR; tel. 09277-67433/63320. Product areas 8. Contact Mr R. K. Beach, Director.

Radiological Protection Services Ltd
61 Lind Road, Sutton, Surrey SM1 4PP; tel. 081-643 6374. Product area 8. Contact B. H. Cutting, Managing Director.

Quantel Ltd
Administration Centre, Kiln Road, Newbury, Berkshire RG13 2HA; tel. 0444 232323. Product areas 2, 10. Contact Mr Christopher Trim, Publicity Officer.

Schering Health Care Ltd
The Brow, Burgess Hill, West Sussex RH15 9NE; tel. 04446-6011. Product areas 1, 2, 3. Contact Mr A. Greaves, Product Manager.

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Meetings and Courses

As a service to our readers, notice of meetings or courses will be inserted free of charge. Please send full details to the Honorary Editor, BIR Bulletin.

Interventional Neuroradiology: Current Practices and Techniques
September 16–18, 1990
Baltimore, USA
Further details: Program Coordinator, The Johns Hopkins Medical Institutions, Office of Continuing Education, Turner Building, 720 Rutland Avenue, Baltimore, Maryland 21205. Tel: 301 955-2959.

Course on Molecular Biology for Cancer Epidemiologists
September 18–27, 1990
Lyon, France
Further details: The Unit of Education and Training, International Agency for Research on Cancer, 150, cours Albert Thomas, 69372 Lyon Cedex 08, France.

23rd Annual Meeting of the European Society for Radiation Biology
September 23–26, 1990
Dublin, Ireland
Further details: Dr C. B. Seymour, Radiobiology Research Group of the Nuclear Energy Board, Geological Survey of Ireland, Beggars Bush, Dublin 4, Ireland. Tel: 01 609511, Ext. 420.

Radiology in Britain and Belgium
September 23–30, 1990
Eastbourne and Brussels
Further details: Mrs Betsy Birchenough, Department of Radiology, University of Connecticut Health Center, Farmington, CT 06032, USA. Tel: 203 679 3322.

The Oxford Course in ENT Radiology
September 28–29, 1990
Oxford
Further details: Mrs S. Cook, Academic Secretary, Department of Otolaryngology, The Radcliffe Infirmary, Oxford OX2 6HE.

Riyadh Armed Forces Hospital Third International Course on Magnetic Resonance Imaging
October 14–17, 1990
Riyadh, Saudi Arabia
Further details: Department of Medical Studies, Armed Forces Hospital, PO Box 7897, Riyadh 11159, Kingdom of Saudi Arabia. Tel: 9661 477 7714, Ext. 2289/2269

Third International Imaging Course
October 29–November 4, 1990
Shatin, Hong Kong
Further details: Miss Rebecca Tsui, Department of Radiology, Prince of Wales Hospital, Shatin, Hong Kong. Tel: 6363213, Fax: 6360012.

Radiotherapy for the 90s: a 2-day Meeting
November 8–9,1990
Manchester
Further details: B. Magee/R. D. Hunter, Radiotherapy Department, Christie Hospital and Holt Radium Institute, Wilmslow Road, Withington, Manchester M20 9BX. Tel: 061 445 8123 Ext. 293/310.

1st International Conference on Digital Radiology and PACS
November 11–13, 1990
Bologna, Italy
Further details: Organizing Secretariat, SO.GE.PA.CO, P.zza Costituzione 4 – 40128 Bologna, Italy. Tel: 051-6435111, Fax: 051-6435149.

Advanced Oncology: Head and Neck Cancer
November 23–24, 1990
London
Further details: The Conference Office, The Royal College of Radiologists, 38 Portland Place, London W1N 4DG. Tel: 071-323 3100.

British Medical Ultrasound Society 22nd Annual Scientific Meeting
December 4–6, 1990
Harrogate
Further details: Miss Anne Summers, British Medical Ultrasound Society, 36 Portland Place, London W1N 3DG.

Personal Dosimetry — Present and Future
January 22, 1991
London
Further details: Dr D. N. S. Dixon, Programme Committee Secretary, The Society for Radiological Protection, 67 Oatlands Park, Linlithgow, West Lothian EH49 6AS. Tel: 031-244 2779.

The Seventh International Conference on Chemical Modifiers of Cancer Treatment
February 2–5, 1991
Florida, USA
Further details: Ms Suzanne Bohn, Projects Coordinator, American College of Radiology, 1101 Market St, 14th Floor, Philadelphia, PA 19107, USA. Tel: 215 574-3181. Abstract deadline: September 21, 1990.

Tumor Response Monitoring and Treatment Planning
April 1–13, 1991
Munich, FRG
Further details: GSF Kongressdienst, Ingolstädter Landstrasse 1, D-8042 Neuherberg, Federal Republic of Germany. Tel: (089) 31872669.

8th International Workshop on Bone Dosimetry
April 28–May 2, 1991
Bad Reichenhall, Germany
Further details: Dr Deiter Felsenberg, Freie Universität Berlin, Klinikum Steglitz, Hindenburgdamm 30, D-1000 Berlin 45, Germany.

Radiology 91
May 2–4, 1991
Brighton
Further details: The Conference Office, The British Institute of Radiology, 36 Portland Place, London W1N 4AT. Tel: 071-580 4085.

American Radium Society Annual Meeting
May 4–8, 1991
Paris, France
Further details: Office of the Secretariat, American Radium Society, 1101 Market Street, 14th Floor, Philadelphia, PA 19107, USA. Tel: (215) 574 3179.

9th International Congress of Radiation Research
July 7–12, 1991
Toronto, Canada
Further details: 9th International Congress of Radiation Research, 1891 Preson White Drive, Reston, VA 22091, Canada. Tel: (703) 648-3780. Deadline for abstracts: January 15, 1991, and for Junior Investigators Awards: October 15, 1990.

European Congress of Radiology '91
September 15–20, 1991
Vienna, Austria
Further details: The Congress Secretariat ECR '91, c/o Vienna Academy of Postgraduate Medical Education and Research, Alser Straße 4, A-1090 Vienna, Austria. Tel: (1) 421383, Fax: (1) 42138323.

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Basic Clinical Ultrasound Hylton B Meire and Pat Farrant, 1982 (BIR Teaching Series No 4) 170 pp., ISBN: 0 905 74910 3	£12.50
Special Report 17: High Dose Rate Afterloading in the Treatment of Cancer of the Uterus, 1980, 200 pp., ISBN : 0 905 74907 3	£18.50
Report 18: Technical and Physical Parameters for Quality Assurance in Medical Diagnostic Radiology, 1989, 166 pp., ISBN: 0 905 74918 9	£30.00
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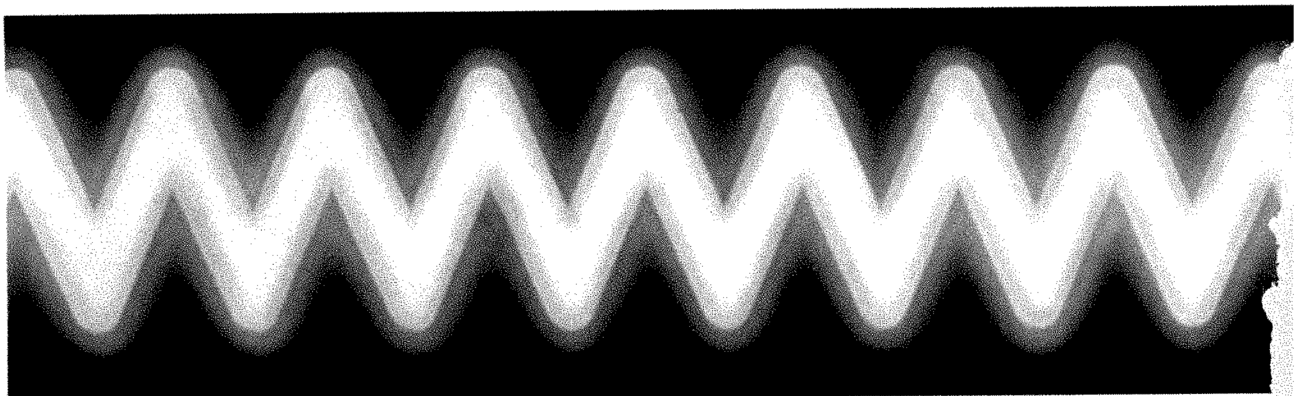

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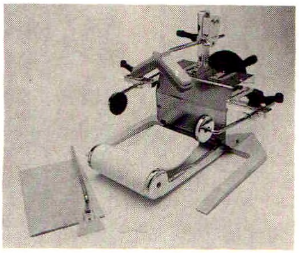

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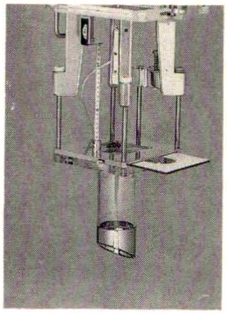

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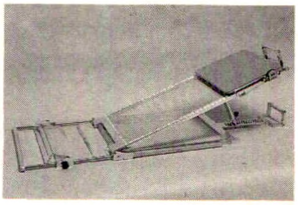

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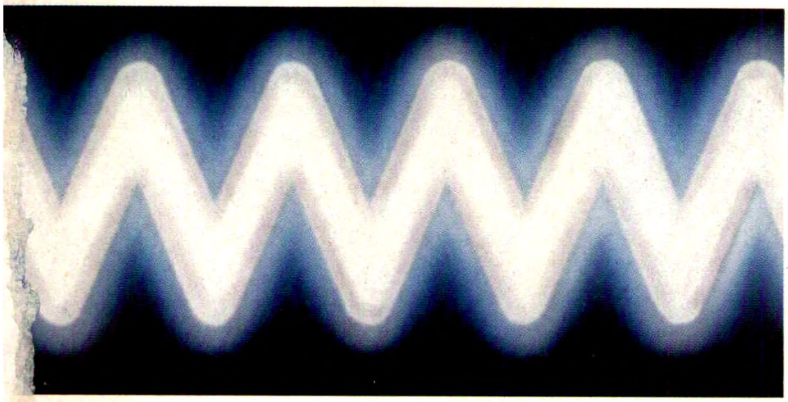

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NEW FROM BIR

OPTIMIZATION OF IMAGE QUALITY AND PATIENT EXPOSURE IN DIAGNOSTIC RADIOLOGY

(BIR Report 20)

Editors:

B M Moores, *Radiation Protection Service, Liverpool, UK*
B F Wall, *National Radiological Protection Board (NRPB), UK*
H Eriskat, *Commission of the European Communities (CEC), Luxembourg*
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Key components in quality assurance in diagnostic radiology are image quality and patient exposure. Quality criteria defining optimum procedures should ensure that the most accurate and reproducible diagnostic information is obtained from radiographs, but at the same time minimize exposure of the patient to ionizing radiation. Formulation of such criteria was the aim of a workshop organized jointly by the CEC and NRPB, of which this book is the edited proceedings. A revised list of quality criteria for common diagnostic examinations was drawn up by a CEC Study Group and is appended to the proceedings.

Contents: Introduction • Image Perception • Physical Assessment of Image Quality • Clinical Assessment of Image Quality • Optimization of Image Quality and Patient Dose – Paediatric Radiology – Mammography – Chest Radiography – Technical Factors • Patient Dose Measurements and Quality Assurance • CEC Image Quality and Exposure Criteria Trial • Panel Discussions • Conclusions and Perspectives for Future Research • CEC Study Group Document on Quality Criteria for Diagnostic Radiographic Images

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NEW FROM BIR

TREATMENT SIMULATORS

(BJR SUPPLEMENT 23)

Editors:

C K Bomford, *Weston Park Hospital, Sheffield, UK*
P J D K Dawes, *Regional Radiotherapy Centre, Newcastle General Hospital, UK*
S C Lillicrap, *Royal United Hospital, Bath, UK*
J Young, *The Middlesex Hospital, London, UK*

BIR Special Report 10 discussed the experiences of the first radiotherapy centres with treatment simulators and drew together a consensus of opinion on the requirements for both technical specification and accommodation as well as drawing up guidelines for future developments. BJR Supplement 16 was a revision of Special Report 10 and reflected the fact that several manufacturers had accepted its recommendations. This latest revision takes account of the developments of the last 7 years and in particular the rapid growth in computer technology, which has meant that the simulator is now at the centre of a network covering the radiation treatment planning computer and the therapy equipment, including recording and verification systems. Linking the treatment planning computer to the CT scanner is discussed and quality assurance is also covered in some detail. This publication will serve as a refresher course for those already using treatment simulators, a comprehensive text for students in radiotherapy, medical physics and radiography, and a useful source of information on technical specifications and practical applications for manufacturers.

Contents: The role of the treatment simulator • Treatment simulator specification • The planning suite • The treatment simulator in practice • Quality assurance • Computers in radiotherapy departments • Other imaging facilities

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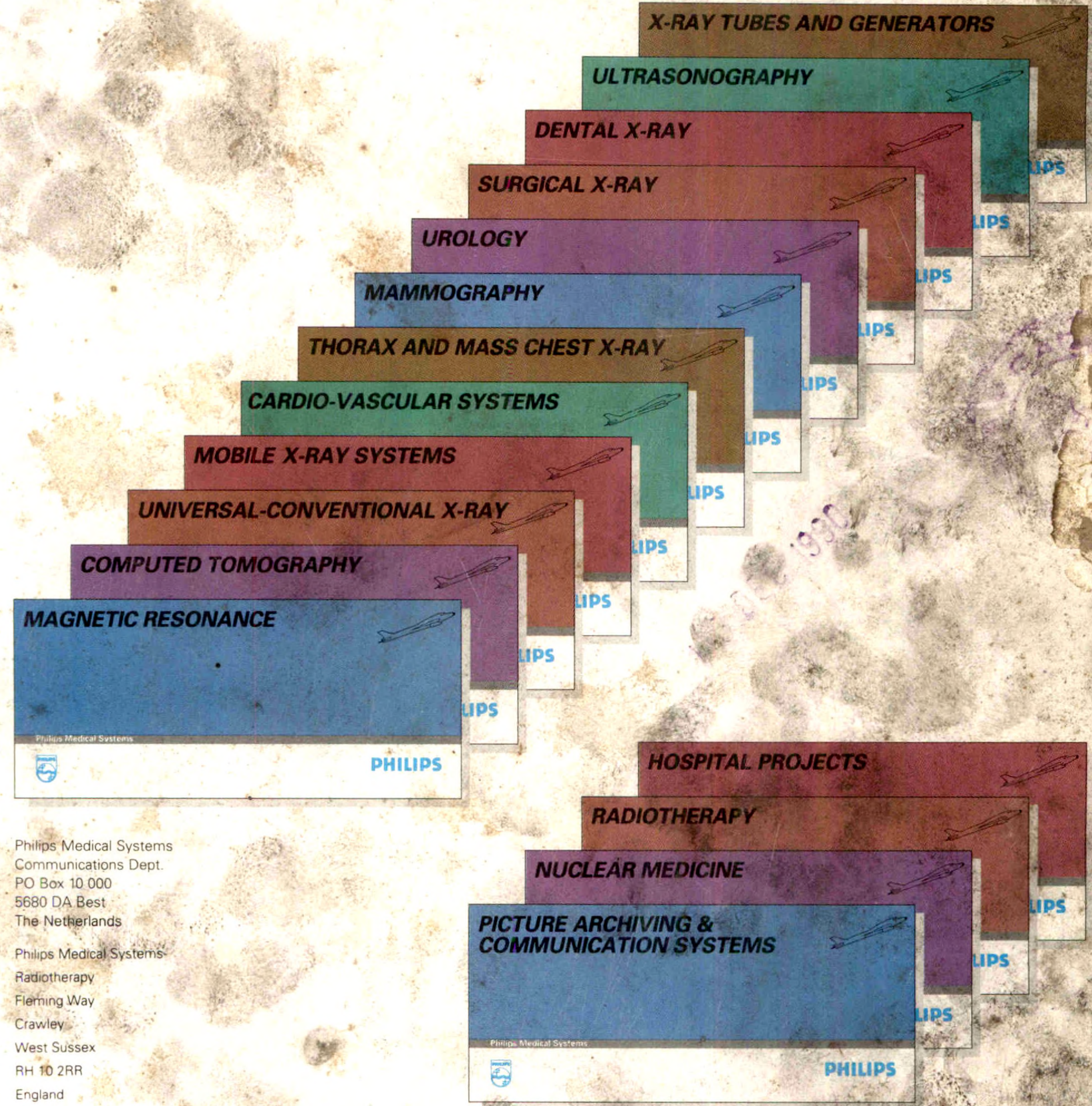

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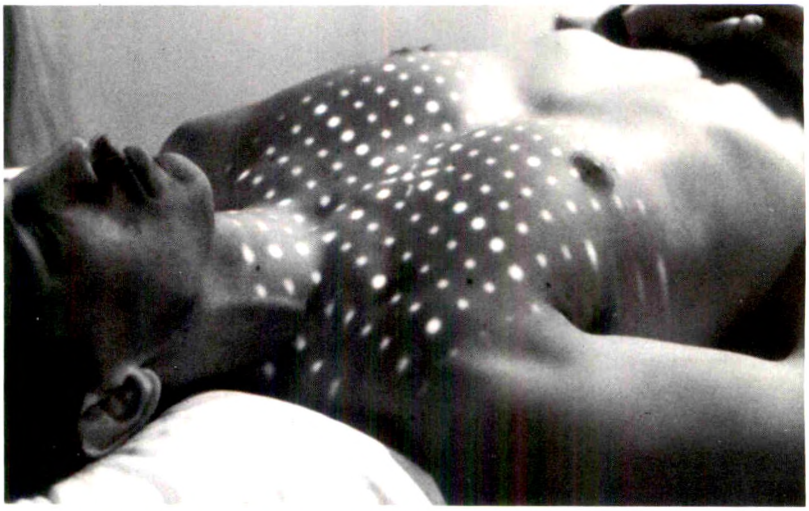

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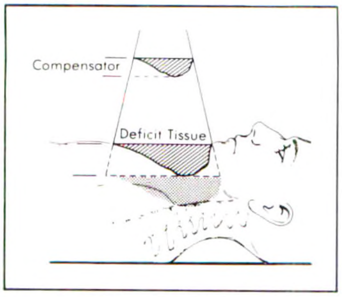

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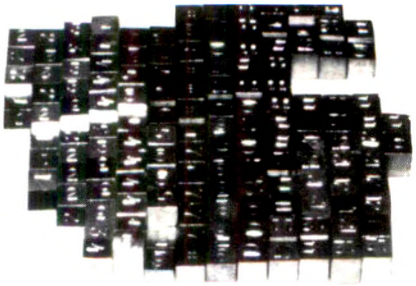

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(BIR Report 21)

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This report is the proceedings of a Workshop held to discuss the current state of knowledge in three studies of the human radiobiology of alpha-emitting radionuclides deposited predominantly in bone: (a) radium dial painters in the USA and UK, (b) German radium-224 therapy cases and (c) patients injected with Thorotrast as an X-ray contrast medium in Germany, Japan and Denmark. Together they present one of the most valuable sources of information on the harmful effects of radionuclides in humans, covering epidemiological aspects, clinico-pathological studies and experimental observations in animals. The information presented will help towards better protection of those exposed to radiation and allow a fuller understanding of the mechanisms by which radiation causes cancer. This publication will be of interest to all those involved in radiotoxicology, radiation protection, health physics and studies of radiation-induced cancer.

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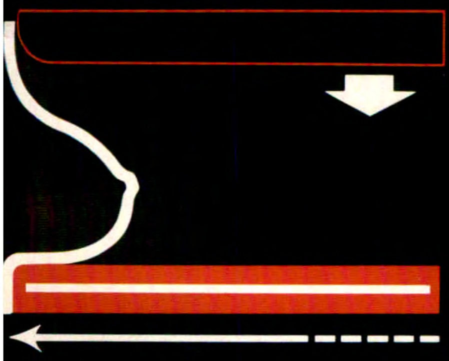

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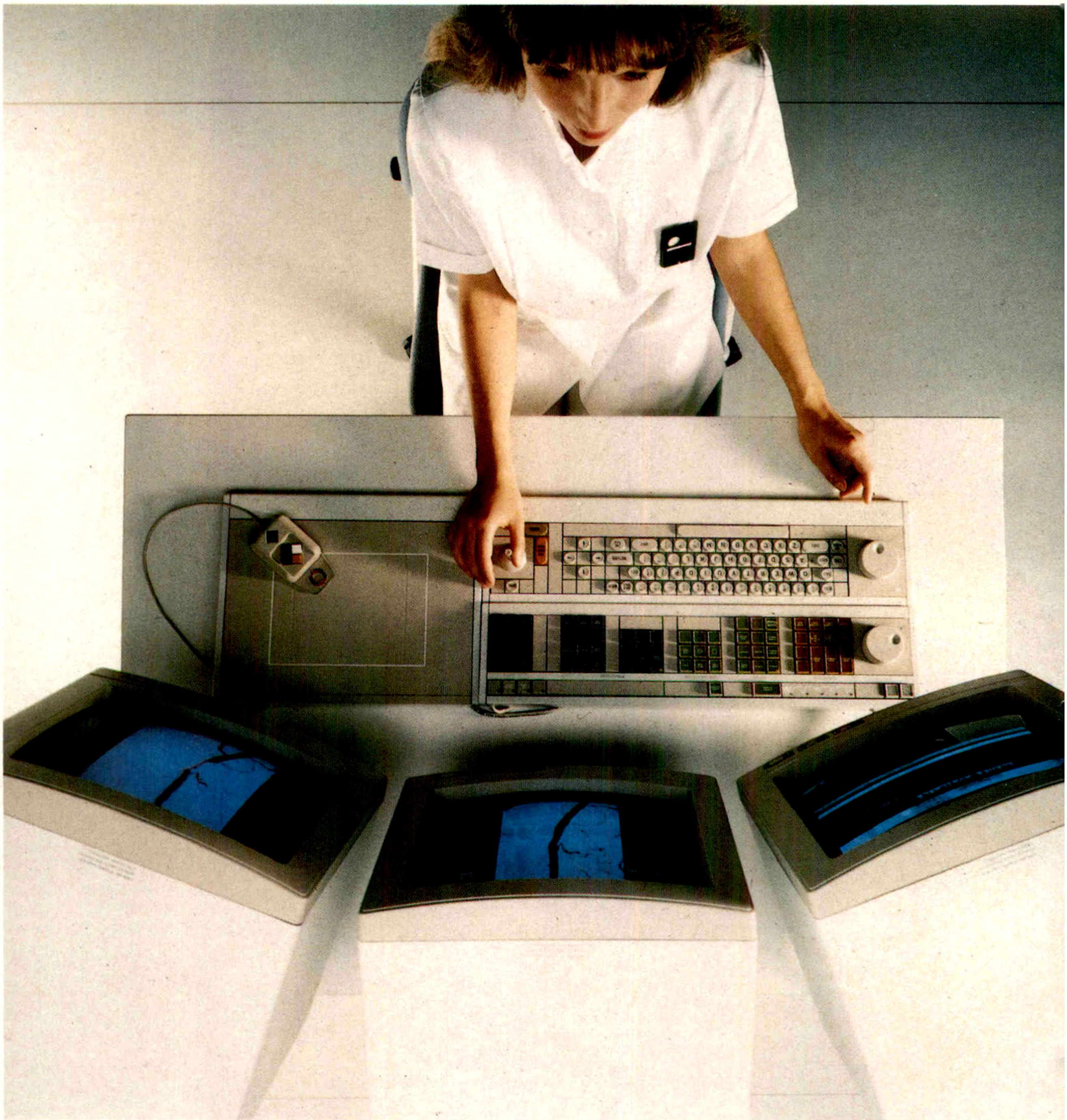

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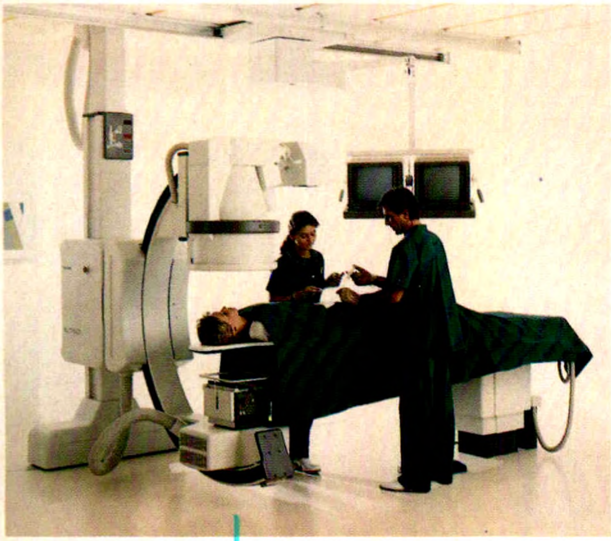

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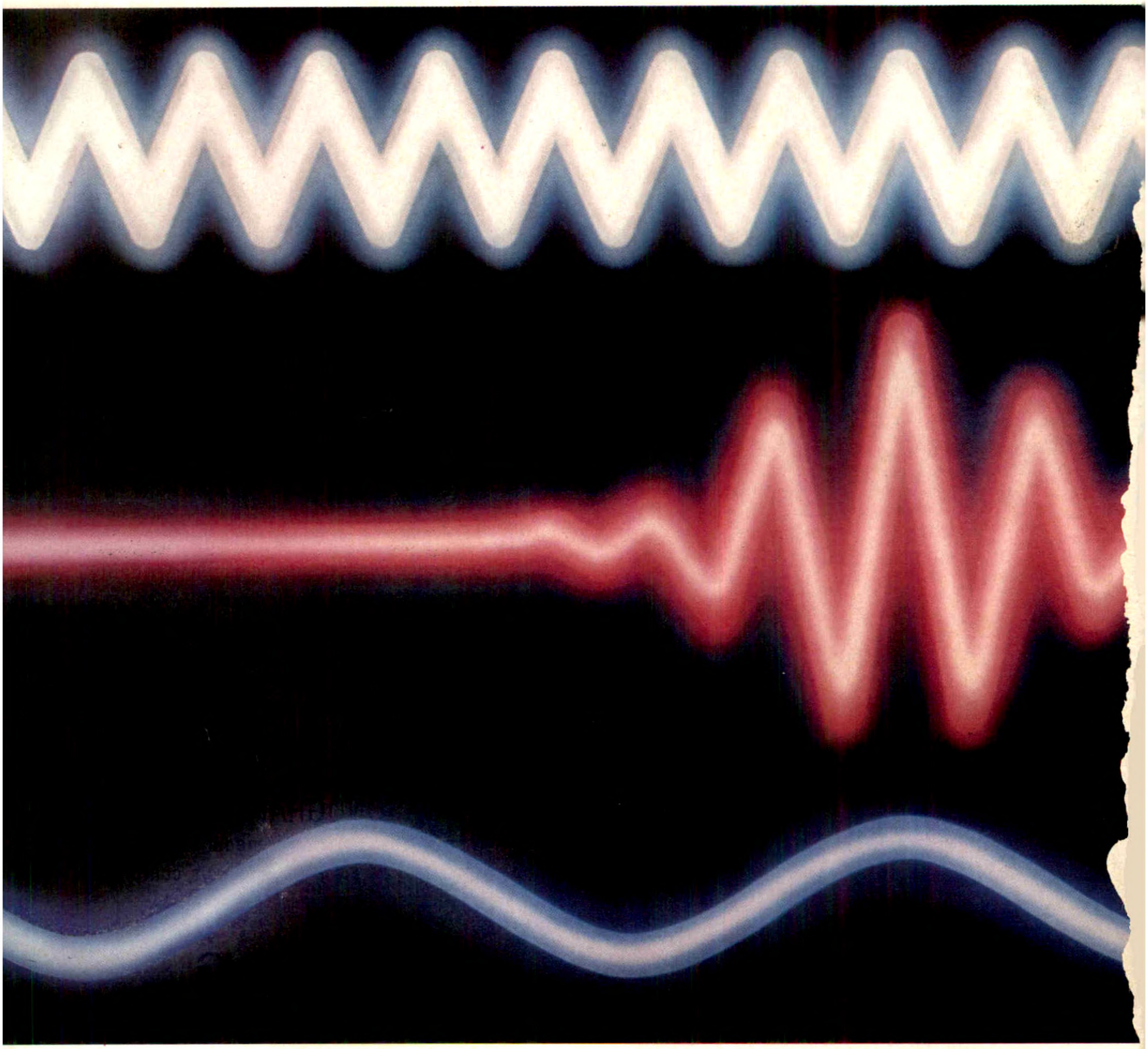

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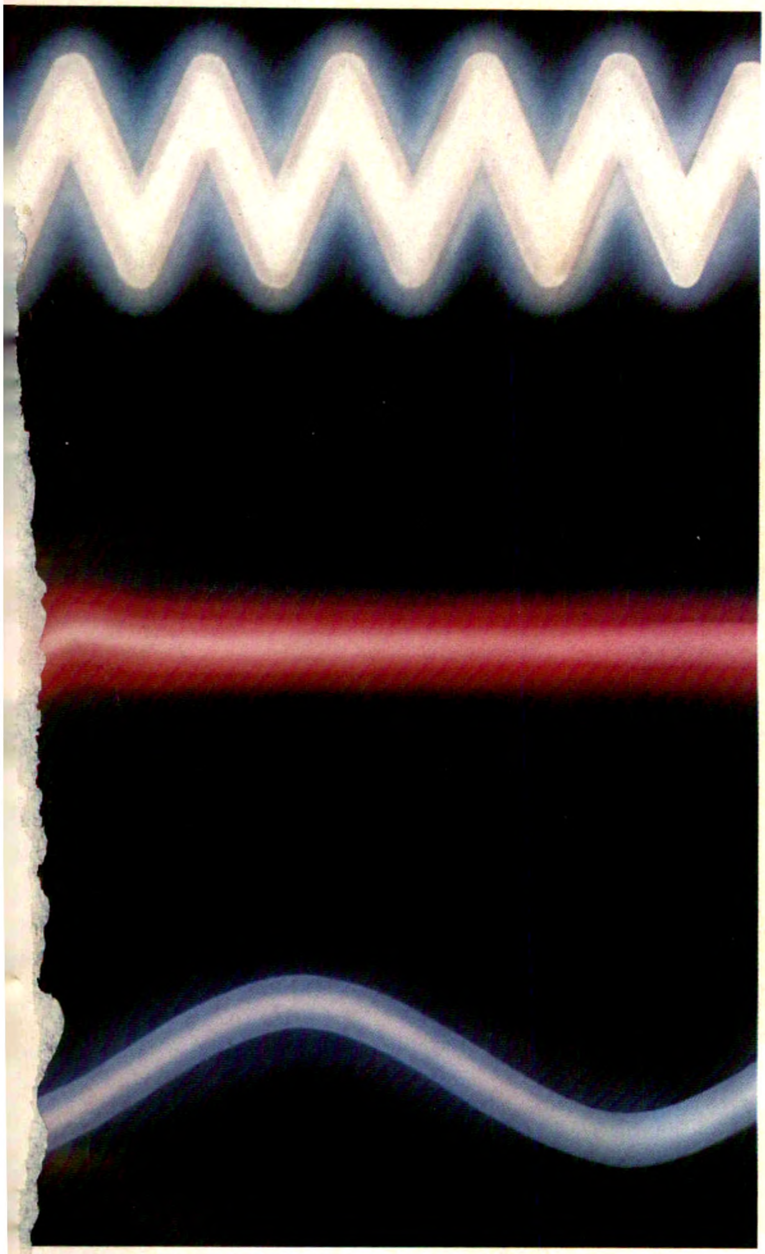

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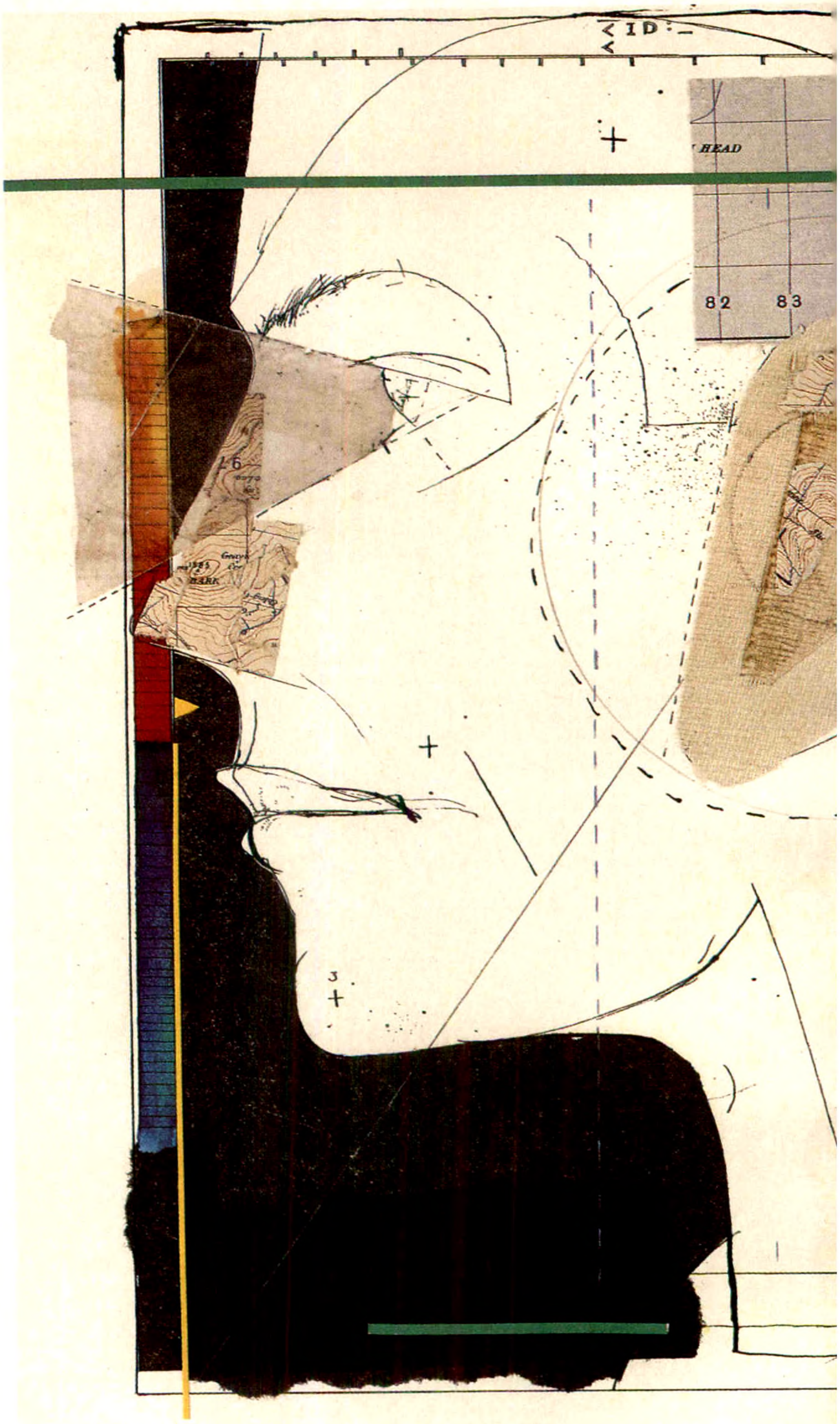

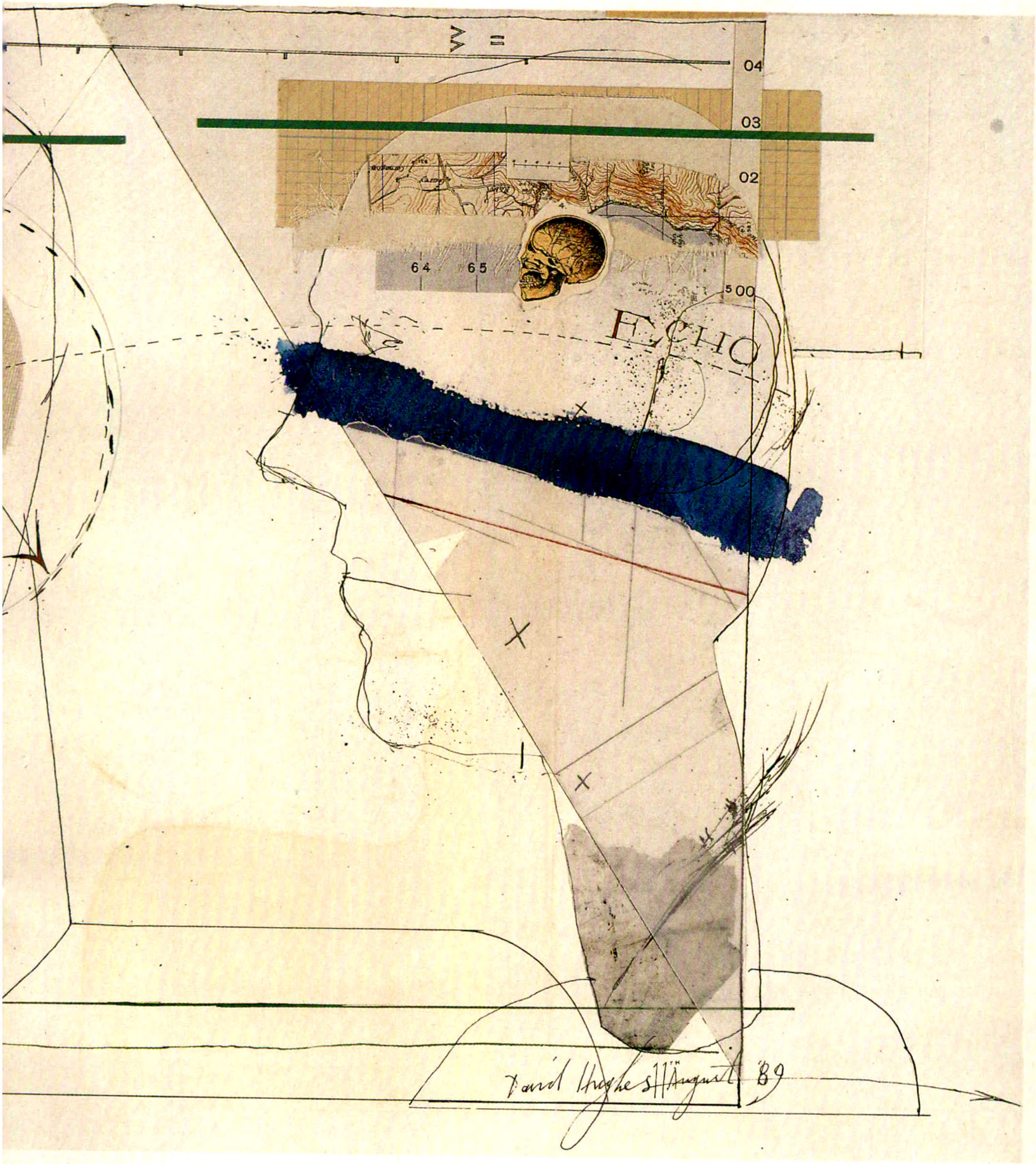

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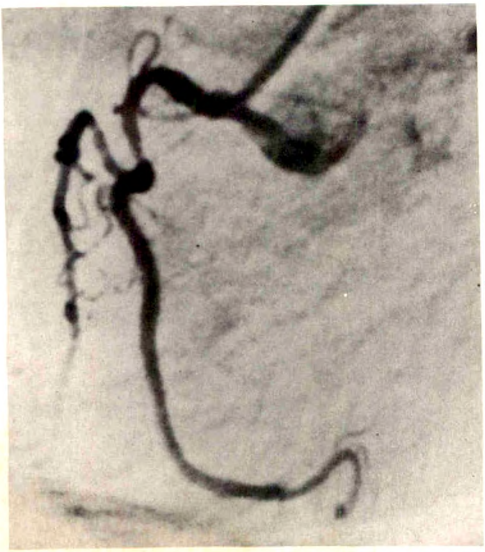

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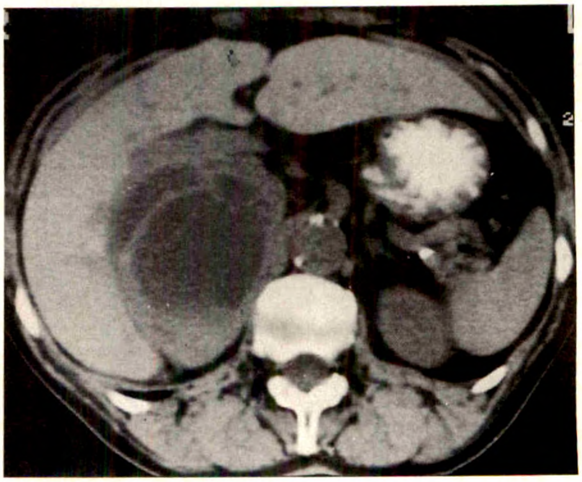

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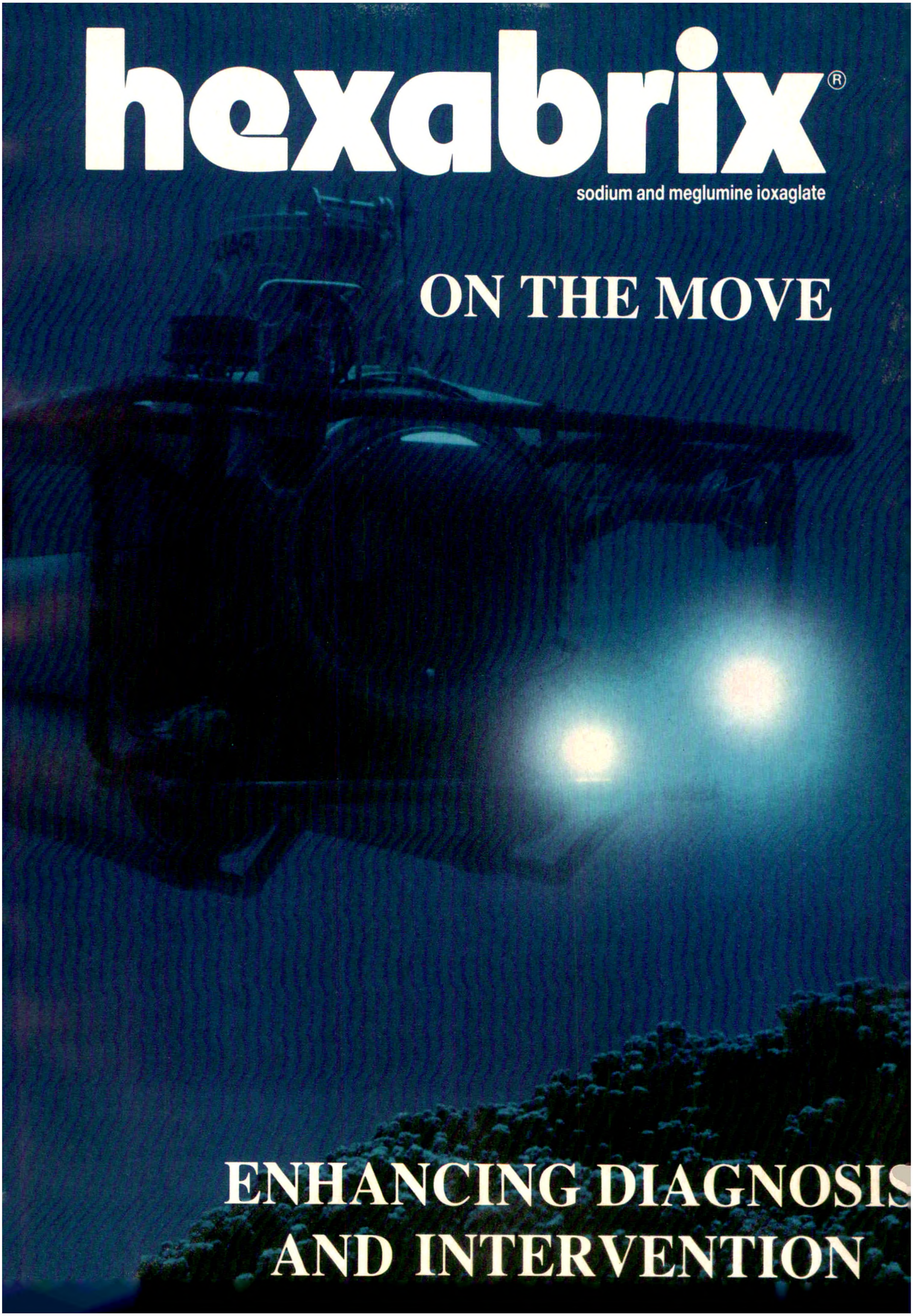

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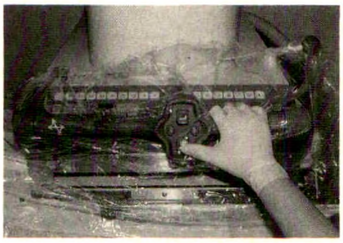

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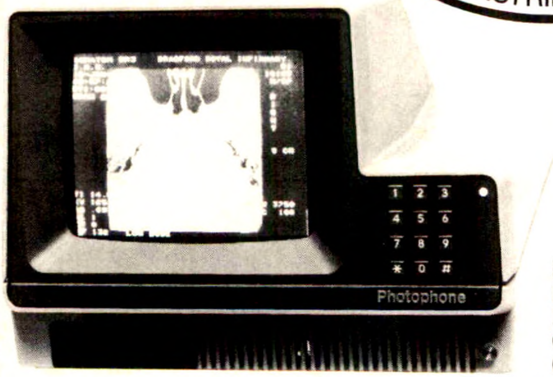

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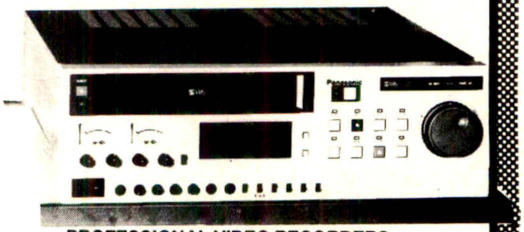

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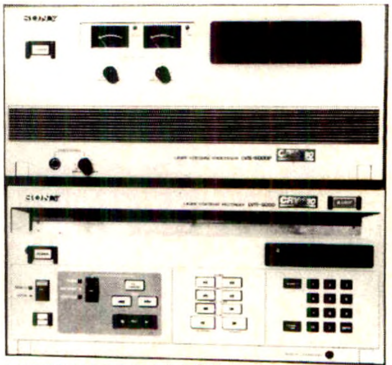

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Deterioration following delay in performing femoral angioplasty

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Abstract. It is not uncommon for a delay to occur between assessment arteriography and angioplasty attempt. We reviewed retrospectively the arteriograms of 61 patients where such a delay occurred to assess progression of superficial femoral artery (SFA) disease in this interval. A mean delay of 14.6 days (range 2–60 days) occurred between arteriogram and angioplasty attempt. Arteriographic deterioration was found in six of 61 patients (9.8%) and in three this precluded angioplasty. Of the six patients four had initial arteriography via the same side as the SFA disease whilst two had arteriography via the contralateral femoral approach. We discuss the aetiology of this phenomenon and suggestions are made to reduce its incidence.

When there is delay between diagnostic lower limb arteriography and angioplasty attempt, arteriographic deterioration may occur in the interim. In certain cases angioplasty may no longer be possible. Early deterioration following arteriography has been previously reported (van Andel, 1980; Gallino et al, 1983) but without analysis of the influence of arterial puncture site or other patient factors in this progression to arterial occlusion. A retrospective study has been performed to assess the frequency of this early deterioration and its relationship to the site of arterial puncture and other variables at assessment arteriography.

Patients and methods

The arteriography register of the department was examined retrospectively for a 2 year period to identify all patients with peripheral vascular disease where there had been an interval of greater than 24 h between the initial assessment arteriogram and the subsequent attempt at SFA angioplasty. Patients had initial transfemoral arteriography as in-patients. There was no specific policy during the period of study regarding side of puncture chosen for assessment arteriography.

The appearances of the SFA at initial arteriography were compared with the direct pre-angioplasty femoral arteriogram. The arteriogram pairs were scored in two categories: (1) no difference; (2) worsening of the SFA appearances such that the angioplasty attempt was either more difficult or impossible. To assess the influence of the puncture site, the patients were subdivided into those where the initial arteriogram puncture had been ipsilateral to the angioplasty attempt and those where it had been contralateral. The interval of delay and the age and sex of the patients were recorded. Where the arteriograms were scored into category 2 the patients' notes were studied to identify any initial or post-arteriogram complication which might have a bearing on the observed SFA deterioration. The extent and severity of SFA disease was compared with age- and sex-matched category 1 patients.

Results

Of the 61 patients whose arteriograms were assessed, 34 were female and 27 male. For 33 patients the assessment arteriogram puncture had been ipsilateral to the SFA intended for angioplasty and for 28 patients a contralateral puncture had been used. These subgroups are compared in Table I. Four of the six patients in whom deterioration of the SFA appearances occurred had an initial ipsilateral study but this observation was not statistically significant. Details of the arteriographic deterioration of these patients are shown in Table II. No immediate complications were recorded to account for these findings in five of the patients. A sixth patient whose SFA disease was contralateral to the initial right-sided puncture site experienced a general urticarial reaction during arteriography and was noted to be hypotensive at the end of the procedure. The event responded to intravenous fluids but this episode may have some bearing on the early progression to complete occlusion of his left SFA. There were no features on their assessment arteriograms to suggest more severe lesions in the

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Table I. Incidence of arteriographic deterioration of SFA disease according to puncture site

Site	Patients	Age (years)	Delay interval	Incidence
Ipsilateral	33	67.2 mean (56–83)	13.7 days mean (2–58 days)	4/33[a]
Contralateral	28	72.5 mean (50–88)	15.6 days mean (2–60 days)	2/28

[a]Difference not statistically significant.

Table II. Nature and significance of SFA deterioration

Age (years)	Sex puncture outcome		Delay (days)		Deterioration
74	F	Ipsilateral	2	Longer occlusion (3 cm into 5 cm)	Successful angioplasty
56	F	Ipsilateral	15	Multiple stenoses into short occlusion (3 cm)	Successful angioplasty
62	M	Ipsilateral	14	Short stenosis into occlusion from origin	Angioplasty impossible, successful surgery
70	F	Ipsilateral	7	Two short stenoses into occlusion from origin	Angioplasty impossible, unfit for surgery
73	M	Contralateral	25	Multiple stenoses into long occlusion (10 cm)	Angioplasty deferred, successful surgery
83	M	Contralateral	7	Single short stenosis into occlusion from origin[a]	Angioplasty impossible, unfit for surgery

[a]Patient experienced hypotensive episode during arteriography.

complications group than individuals showing no worsening of arteriographic appearances. The patients had an average age (69.7 years) similar to that of the overall study group and had no other specific risk factors, *e.g.* diabetes mellitus.

Discussion

Femoro-popliteal angioplasty is now performed in most radiology departments and its use has grown rapidly in recent years (Cumberland, 1988). A close liaison and understanding is required between radiologist and vascular surgeon to maximize its benefits and to define clearly the role and capability of angioplasty in each centre. Grading systems have been described to assess suitability of patients for angioplasty (Campbell et al, 1988).

The patient is best served when assessment arteriography can proceed to angioplasty attempt without delay. With this in mind the identification of patients for whom SFA-angioplasty would be the treatment of choice and the freedom to proceed are as important to the radiologist as the arteriographic delineation of suitable lesions. There are important implications for the provision of space on arteriography lists and a need for prior informed consent to minimize delays. We believe that the incidence of early deterioration in the SFA shown in this series makes it important to reduce the need for interval angioplasties.

The aetiology of early deterioration in the SFA following arteriography is unclear. The early occurrence of deterioration suggests it could be a true complication of arteriography rather than inevitable progression of SFA disease. Serial arteriographic studies in patients with lower limb arterial disease suggest a slow progression of the atheromatous disease process (Dawson & Raphael, 1968). The commonest deterioration in the SFA was of irregularity or stenosis proceeding to occlusion during a follow-up of 2 years. Similar deterioration from femoral artery stenosis to complete occlusion was noted in 53% of cases with an arteriographic follow-up of 25 months (Kuthan et al, 1971). The possibility that the arteriographic study itself may precipitate or accelerate this deterioration has been previously postulated (van Andel, 1980). In his series of six cases, deterioration was noted after ipsilateral, contralateral or translumbar puncture and it was thus suggested that the ionic contrast medium was the likely cause of damage. Our series also failed to demonstrate a statistically significant correlation with puncture site.

Other authors have been reluctant to ascribe the acceleration of the obstructive process to the arteriography (Gallino et al, 1983). Deterioration was described in 18% of their patients restudied at a mean interval of 7 weeks. No relationship to puncture site or severity of stenosis was indicated.

Early thrombosis of the common femoral artery is usually attended with obvious clinical features of arterial obstruction in the limb (Sigstedt & Lunderquist, 1978). The results of occlusion of an already diseased SFA are not so well documented and are probably influenced by the extent of collateral circulation. None of our patients reported a clinical deterioration in accordance with previous reports (van Andel, 1980). Interestingly, his patients were either anti-coagulated or treated with anti-platelet medication in the interval between arteriography and angioplasty attempt but thrombotic deterioration still occurred.

Arteriographic techniques have been refined in recent years with the use of smaller calibre catheters and non-thrombogenic guidewires. The introduction of low-osmolar contrast media and digital subtraction techniques (as used in our series) have further reduced the endothelial insult. Nevertheless, 10% of patients have been shown to have early and significant arteriographic deterioration following their assessment study. The exact cause for this remains unclear. Arteriography has been likened to "a squall shaking a ripe apple from a tree which would have fallen itself in due time" (van Andel, 1980). Angioplasty should follow arteriographic assessment with the minimum of delay before the apple turns rotten!

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Gallbladder wall thickening (congestive cholecystopathy) in chronic liver disease: a sign of portal hypertension

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Abstract. A thickened gallbladder wall is often seen with ultrasound in alcoholic cirrhosis. Hypoalbuminaemia is thought to be the cause since there is a strong association between bowel wall thickening and low serum albumin. To determine the role of portal hypertension in producing gallbladder wall thickening we studied 40 consecutive stable patients—37 with cirrhosis and three with portal hypertension due to primary biliary cirrhosis. Ultrasound assessment of the gallbladder wall was made after an overnight fast using a Technicare autosector. Wall thickness 4 mm or greater was considered abnormal. Twenty-seven patients had a thickened gallbladder wall and all had evidence of portal hypertension. Hypoalbuminaemia was not an important factor since it was only present in six cases with thickened walls. In two cases reduction in portal pressure with oral propranolol was associated with a decrease in gallbladder wall thickness. These results suggest that portal hypertension, not hypoalbuminaemia, is the dominant factor causing gallbladder wall thickening in cirrhosis. Ultrasound demonstration of gallbladder wall thickening in chronic liver disease should suggest the presence of portal hypertension.

Thickening of the gallbladder wall detected by ultrasound was first described in association with acute cholecystitis (Marchal et al, 1978; Handler, 1979; Joseph, 1983). Recent studies have reported gallbladder wall thickening in other conditions, in particular alcoholic liver disease (Fiske et al, 1980; Sanders, 1980; Ralls et al, 1981). The cause of the thickening is controversial. Hypoalbuminaemia is widely regarded to be the major factor by analogy with the well documented association between bowel wall thickening and low serum albumin (Marshak & Linder, 1976; Farthing et al, 1981). Several studies have supported this association. Out of 42 patients with thickened gallbladder wall, the majority of whom had alcoholic liver disease, 40 had hypoalbuminaemia while the remaining two had acute cholecystitis (Ralls et al, 1981). However, there are alternative suggestions of the cause of gallbladder thickening in chronic liver disease, including the presence of ascites (Patriquin et al, 1983), alcoholic hepatitis (Laudanna et al, 1987) and portal hypertension (Ralls et al, 1981; Tsujimoto et al, 1981).

Previous attempts at assessing the cause of gallbladder thickening have studied acutely ill patients where hypoalbuminaemia, ascites, alcoholic hepatitis and portal hypertension have often been present simultaneously, making assessment of their relative contributions difficult.

Our aim was to evaluate the role of portal hypertension in producing gallbladder thickening by studying stable out-patient cirrhotics of alcoholic and non-alcoholic aetiology where the influences of hypoalbuminaemia, alcoholic hepatitis and ascites are minimized.

Patients and methods

Forty consecutive patients with biopsy-proven liver disease were studied. Thirty-seven had established cirrhosis (20 alcoholic and 17 non-alcoholic), while three had primary biliary cirrhosis with portal hypertension. All patients were ambulant out-patients studied at least 1 month after any episode of gastrointestinal bleeding or alcoholic hepatitis. Two patients had chronic ascites. No patient had clinical evidence of acute cholecystitis.

Gallbladder wall thickness 4 mm or greater was considered abnormal (Fiske et al, 1980; Ralls et al, 1981; Patriquin et al, 1983). Ultrasound examination of the gallbladder was carried out in the morning after an overnight fast of at least 8 hours. A Technicare autosector with a 5 MHz probe was used. The gallbladder was scanned along its long axis with the patient supine or in the right anterior oblique position. Measurements of the thickness of the anterior wall of the gallbladder were made in a plane where the ultrasound beam was perpendicular to the wall (Maudgal et al, 1984) (Fig. 1).

During the ultrasound examination, gallstones and ascites were also looked for. Portal hypertension was assessed both by upper gastrointestinal endoscopy for oesophageal varices and ultrasound examination for splenic hilar, periportal and retroperitoneal varices. In two cases portal pressure (wedge to free hepatic vein pressure (W-F HVP) and gallbladder wall thickness were measured before and after 3 month's treatment with propranolol (160 mg and 80 g daily) respectively. A serum albumin estimation was made within 1 week of the ultrasound examination.

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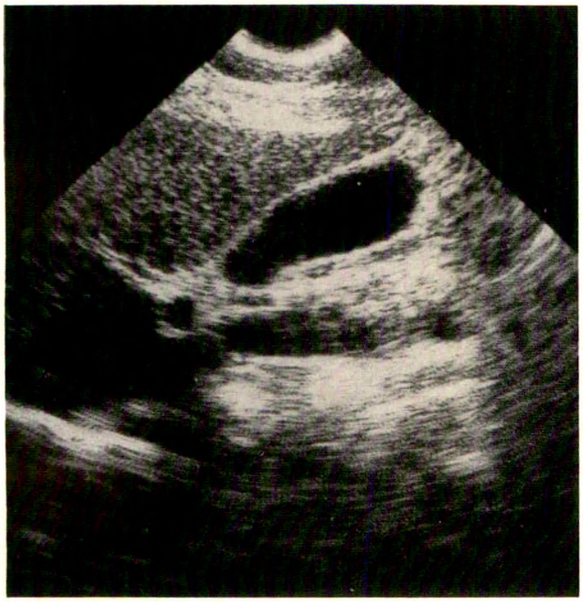

Figure 1. Long axis scan of a normal gallbladder.

Results

Gallbladder wall thickness ranged from 1 to 11 mm, with 27 patients (68%) having a gallbladder wall thickness of 4 mm or greater (Fig. 2). A thickened gallbladder wall was seen in both alcoholic (12 cases) and non-alcoholic (15 cases) aetiology. All patients with a thickened gallbladder wall had evidence of portal hypertension—either oesophageal varices (21 cases) or other portosystemic collaterals (six cases). W-F HVP was measured in two patients and found to be raised 20 mm and 22 mm, respectively (normal < 5 mmHg). Following 3 months propranol W-F HVP fell by 12 mm (60% and 55%) respectively, associated with a decrease in gallbladder wall thickness by 50% in both patients. Gallstones were demonstrated in 11 cases but showed no correlaiton with gallbladder wall thickening. Hypoalbuminaemia was not an important factor in our cases since, in 21 of the 27 cases (81%) with a thickened gallbladder wall, serum albumin was greater than 35 g/l. No correlation was found between the degree of gallbladder thickening and serum albumin (Fig. 3). Both cases with ascites had a low serum albumin and thickened gallbladder wall.

Thirteen patients had a gallbladder wall thickness of 3 mm or less—seven with evidence of portal hypertension while six had neither oesophageal varices nor other portosystemic collaterals demonstrable.

Discussion

Since gallbladder wall thickening was originally described in acute cholecystitis there have been numerous reports of this ultrasound sign being present in other conditions including ascites, hypoalbuminaemia, right-sided heart failure, renal diease, infectious hepatitis and alcoholic hepatitis (Fiske et al, 1980; Sanders, 1980; Levandowski & Winsberg, 1981; Ralls et al, 1981; Shaler et al, 1981; Tsujimoto et al, 1981; Patriquin et al, 1983; Maudgal et al, 1984; Kaftori et al, 1987; Laudanna et al, 1987). In cholecystitis the cause of the

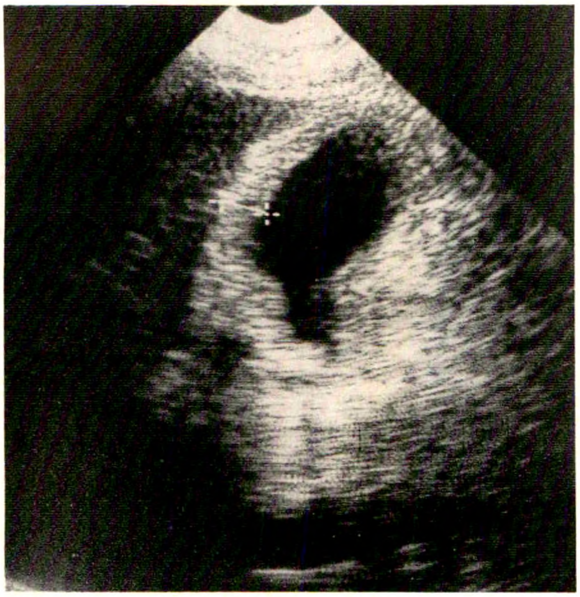

Figure 2. Long axis scan of a patient with portal hypertension and normal albumin level showing a grossly thickened gallbladder wall (crosses).

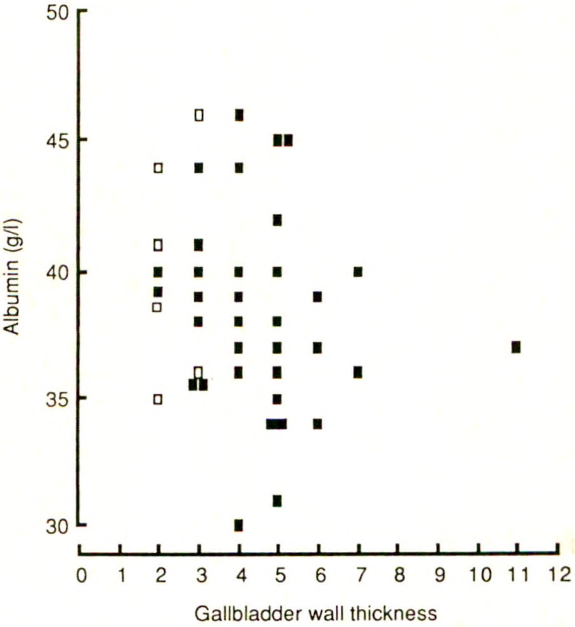

Figure 3. Serum albumin (in patients with portal hypertension (■) and without demonstrable portosystemic collaterals (□) and gallbladder thickness.

thickening is local inflammation of the gallbladder wall giving rise to subserosal oedema, and this has also been suggested to be the mechanism accounting for thickening in infectious hepatitis.

In chronic liver disease, other factors must play a role and the presence of ascites, hypoalbuminaemia and portal hypertension have all been implicated in causing gallbladder wall thickening. The association between ascites and gallbladder wall thickening may just be secondary to the frequent association of ascites with both hypoalbuminaemia or portal hypertension. Our results demonstrating ascites in only two of 27 cases with thickened gallbladder walls are against it being a causal factor. Most authors felt that hypoalbuminaemia is the major determinant for the gallbladder wall thickening (Fiske et al, 1980; Ralls et al, 1981; Shaler et al, 1981; Patriquin et al, 1987). However, the present study clearly shows that hypoalbuminaemia is not an important factor in gallbladder wall thickening in stable cirrhotics of both alcoholic and non-alcoholic aetiology. A recent study in hypoalbuminaemic patients on chronic peritoneal dialysis supports this view. No patient even with markedly lowered serum albumin levels had a thickened gallbaldder (Kaftori et al, 1987).

Our data suggest that portal hypertension is the dominant factor in producing gallbladder wall thickening in stable cirrhotics. Although we showed that portal pressure was elevated by W-F HVP measurements in only two patients, all our patients with thickened gallbladder walls had evidence of portal hypertension by the demonstration of either oesophageal varices or other portosystemic collaterals. Furthermore, in both patients treated with propranolol, portal pressure reduction was associated with a decrease in gallbladder wall thickness. There is therefore support for our view that portal hypertension is an important influence on gallbladder wall thickness. Ralls et al (1981) found the portal vein diameter to be larger in patients with thickened gallbladder walls compared with normal gallbladder walls. Although most of their patients were hypoalbuminaemic they found a better distinction between normal and thickened gallbladder walled patients by portal vein diameter measurements than by serum albumin measurements. Tsujimoto et al (1981) found that three out of 15 cirrhotics with ascites and a thickened gallbladder had serum albumin levels greater than 35 g/l. All three had evidence of portal hypertension.

Portal hypertension is a recognized finding in right heart failure (Farthing et al, 1981; Patriquin et al, 1983) and may explain the association with thickened gallbladder wall in this condition. A single case reported by Patriquin et al (1983) of gallbladder thickening in association with a blocked Fontan shunt (right atrium-to-pulmonary artery bypass) supports this hypothesis.

The pathological basis for gallbladder wall thickening in liver disease is not known. In one study, post-mortem examination of two patients with thickened gallbladder walls revealed no abnormality (Joseph, 1983). Portal hypertension might be expected to cause gallbladder wall oedema. However, it is now known that a raised portal pressure can produce more subtle changes in the gastrointestinal tract (McCormack et al, 1985). Recent studies have shown thickening of the stomach of cirrhotics by ectatic vessels, a congestive gastropathy (McCormack et al, 1985). We have shown by ultrasound that the stomach is thickened in portal hypertension (Saverymutta et al, 1990). These changes in gastric vasculature are quite subtle and have not been mentioned in previous studies (Brown et al, 1981). The gallbladder changes we have observed in portal hypertension may therefore represent a congestive cholecystopathy. Whether ectatic vessels or oedema is the major cause of gallbladder wall thickening in chronic liver disease will need correlative ultrasound and pathological studies.

This study has been able to demonstrate dissociation between gallbladder thickening and hypoalbuminaemia because of patient selection. Previous studies have examined a large proportion of decompensated patients where the confounding influences of hypoalbumaemia, alcoholic hepatitis, ascites and portal hypertension were present together. The present study clearly shows that hypoalbuminaemia, ascites and alcoholic hepatitis are not necessary to produce gallbladder wall thickening.

Although on the basis of our results we consider that portal hypertension is the dominant factor in gallbladder wall thickening in chronic liver disease, both inflammation and hypoalbuminaemia are important factors in other situations and may play an additive role in chronic liver disease.

By analogy with the systemic circulation, peripheral limb swelling may be the result of venous hypertension, hypoalbuminaemia or infection either individually or in combination. Similarly, gallbladder thickening may be caused by portal hypertension, hypoalbuminaemia or inflammation.

From the clinical viewpoint, in the stable patient with chronic liver disease, if inflammation and hypoalbuminaemia are excluded, a thickened gallbladder wall suggests that portal hypertension is present.

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Computed tomographic assessment of old calcaneal fractures

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Abstract. Prolonged pain and disability are common complications of calcaneal fractures. A prospective study was conducted on the value of computed tomography (CT) in 63 patients with 73 calcaneal fractures sustained more than 6 months before. The fractures were classified from the initial plain radiographs, and the patients' current clinical condition assessed in terms of a "disability score". The mean disability scores (MDS) associated with the different types of fracture were correlated with the CT findings. The highest MDS was found in the intra-articular fracture group which comprised 71% of the series. In this group the MDS was increased in the presence of post-traumatic osteoarthrosis of the subtalar joint (61% of cases), involvement of the calcaneocuboid joint (39% of cases) and subluxation/dislocation of the peroneal tendons (47% of cases). Structural abnormalities of the peroneal tendons were associated with a higher MDS including chronic tenosynovitis (eight cases), chronic partial tendon rupture (eight cases), complete peroneus brevis tendon rupture (two cases) and scarring indicating stenosing tenosynovitis (14 cases). A similar spectrum of appearances affecting the medial tendons of the hindfoot was identified in eight cases. Direct CT measurements of the degree of comminution did not correlate well with the patients' MDS. In the patient with persistent symptoms, CT is of value in the later assessment of long-term complications by revealing abnormalities of the subtalar joints and adjacent tendons.

There is limited agreement about the most appropriate treatment for the acute calcaneal fracture. The role of computed tomography (CT) in the early assessment of these fractures is well established, particularly for pre-operative planning, as shown by the considerable literature on the subject (Guyer et al, 1985; Heger et al, 1985; Pablot et al, 1985; Segal et al, 1985; Gilmer et al, 1986; Hindman et al, 1986; Rosenberg et al, 1987a; Heuchemer et al, 1988; Lowrie et al, 1988). Often, however, it is the late complications of intra-articular calcaneal fractures that can present a difficult clinical problem. To date only a single case report (Techner & Eannace, 1987) and a short series of six cases, with a mean rescan period of 6.5 months (Rosenberg et al, 1987b), have advocated CT in this context. The purpose of this paper is to study prospectively with CT a large number of patients, 6 months or more after sustaining a calcaneal fracture, and to correlate the findings with the patients' clinical condition.

Patients and methods

Review of the X-ray records, principally at the Birmingham Accident Hospital, identified 188 patients with a fracture of one or both calcanei. A letter, indicating the purpose of the study, was sent to the last known address of all the patients of whom 63 (33.5%) agreed to attend for CT. Each fracture was classified from the plain radiographs according to the Schmidt and Weiner modification of the Rowe and Essex-Lopresti classifications of fractures of the calcaneum (Table I) (Essex-Lopresti, 1952; Rowe et al, 1963; Schmidt & Weiner, 1982). Prior to the CT examination a brief history and clinical examination was performed to establish a "disability score" for each patient in terms of a subjective assessment of pain and objective observation of a limp and presence or absence of tenderness and motion of the hindfoot (Table II).

Table I. Calcaneal fractures: classification and incidence (Schmidt and Weiner modification of Rowe and Essex-Lopresti classifications), after Berquist (1989)

Type	Published incidence (%)	Study incidence (%)
1a (tuberosity)	6	12.3
1b (sustentaculum)	3	0
1c (anterior process)	15	9.6
1d (infero-lateral)	1	1.4
2 (achilles avulsion)	4	2.7
3 (linear extra-articular)	19	4.1
4 (linear intra-articular)	10–26	4.1
5a (tongue depression)	5	31.5
5b (joint depression)	43–60	34.2

High resolution CT of the hindfeet was performed on a Siemens DRH whole-body scanner in both coronal and axial planes (Smith & Staple, 1983). Contiguous slices of 4 mm from the tuberosity posteriorly to the calcaneocuboid joint anteriorly (coronal) and from the talus superiorly to the plantar fascia inferiorly (axial) were viewed on bone and soft tissue window settings. The CT examinations were subsequently reviewed and observations regarding bone and soft tissue changes

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Table II. Disability score

Pain	Tenderness	Limp	Hindfoot mobility
Absent = 0	Absent = 0	Absent = 0	Normal = 0
Mild = 1	Present = 1	Present = 1	Reduced = 1
Moderate = 2			Absent = 2
Severe = 3			

Score: Normal = 0, Max. disability = 7.

recorded. The bone changes included identification of the site of the fracture(s), current state of healing, degree of calcaneal compression, post-traumatic osteoarthrosis of the subtalar joints, lateral spur formation and calcaneofibular abutment.

The position and the appearance of the tendons and tendon sheaths around the hindfoot were also noted. On CT of the hindfoot a normal tendon appears as a homogeneous, well defined, round density of higher attenuation than muscle and it is accentuated by the surrounding fat. The following tendon abnormalities were looked for on CT: firstly, chronic tenosynovitis indicated by a halo of fluid distending the synovial sheath surrounding a tendon; secondly, post-traumatic stenosing tenosynovitis indicated by the presence of scar tissue obliterating the normal fat around the tendon; thirdly, chronic partial ruptures seen as increase in girth of the tendon with heterogeneous areas of decreased density within the substance of the tendon itself; fourthly, a complete tendon rupture detected as absence of a portion of the tendon with the defect replaced by either fat or fluid (Rosenberg et al, 1988a).

The CT findings were correlated with the patients' respective mean disability score as were measurements of calcaneal depression, coronal and axial splaying, sustentacular depression and reduced angle and Bohler's angle (Seltzer et al, 1984).

Results

A total of 73 old calcaneal fractures were identified in the 63 patients attending for CT examination (31 right, 22 left and 10 bilateral fractures). There were 47 male patients and 16 female with an age range of 12–85 years (mean 49.7 years). The CT examination was performed a minimum of 7 months after the original injury (range 7–300 months; mean 31.9 months).

The plain film classification and incidence of the different types of calcaneal fracture in this study are summarized in Table I. For the purposes of this study the fractures involving the main posterior subtalar joints (Types 4, 5a and 5b) are categorized as the "intra-articular fracture" group even though some fractures of the anterior process (Type 1c) involved the calcaneocuboid joint. Fifty-one (70%) were intra-articular (Types 4, 5a and 5b), and of the remaining fractures the tuberosity (Type 1a, 12.3%) and anterior process (Type 1c, 9.6%) were the most common sites (Table I).

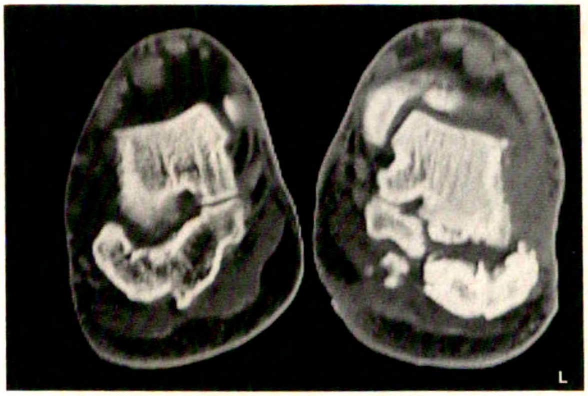


Figure 1. Coronal CT: bone window. Left calcaneal fracture 13 months after injury showing ununited fracture base of sustentaculum.

Bone changes

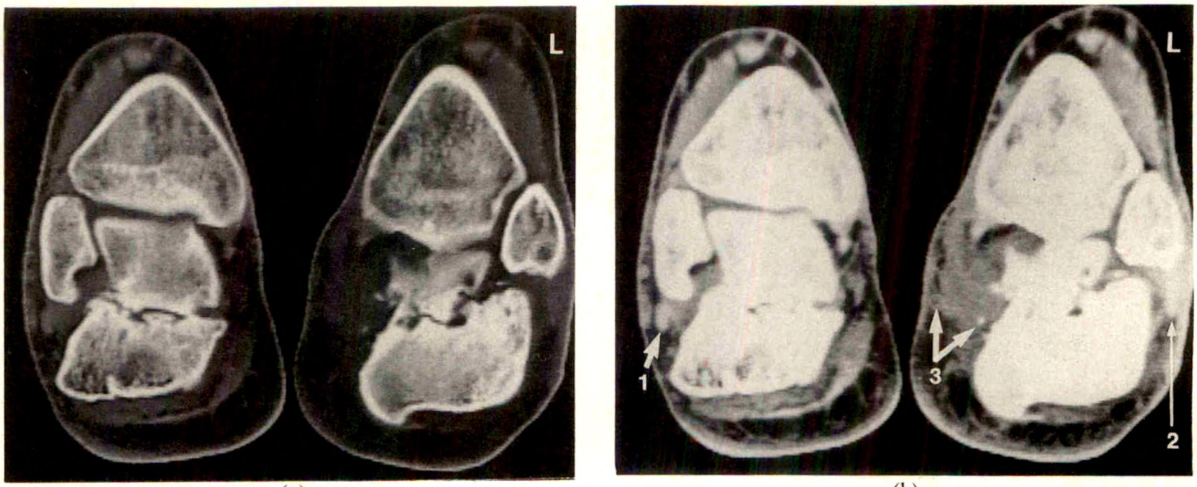
The CT showed that all the non-articular fractures (Types 1a to 3) had fully healed apart from three cases involving the anterior process. In this subgroup of the Type 1 category the fragment of bone avulsed from the anteromedial wall of the calcaneum by the extensor digitorum brevis muscle remained ununited in the adjacent soft tissue. This feature, poorly shown on the anterior coronal images, was easily identified on the axial CT.

In all but two cases the intra-articular fractures were shown on CT to have also united. The exceptions were two severely comminuted joint depression fractures (Type 5b) in which the degree of displacement of the lateral fragment prevented union with the base of the sustentaculum (Fig. 1). Four fractures in which CT had also been performed shortly following the injury showed that, despite marked comminution, further displacement of the bone fragments did not occur.

Post-traumatic osteoarthrosis of the posterior subtalar joint denoted by joint space narrowing and irregularity and a vacuum phenomenon was revealed on the coronal CT in 31 (61%) of the intra-articular fracture group (Figs 2a and 3a). Loose bodies were identified in 12 (23.5%) cases (Figs 2a and 3a) and ankylosis of the posterior subtalar joint in four, of whom two had undergone surgery to arthrodese the joint (Fig. 3a).

There was a spectrum of appearances from minor distortion of the calcaneum (Type 4) to marked depression and splaying (Types 5a and 5b). The flattening of the calcaneum was best demonstrated on the coronal CT (Figs 2a and 3a) whilst the splaying could be identified on both the coronal and axial images. Displacement of the lateral fragment and prominent lateral spurs were shown on the coronal CT to compromise the calcaneofibular space in 41 (80%) cases. The calcaneofibular distance was reduced in 25 (49%) cases (Fig. 2a) and obliterated with calcaneofibular abutment in 16 (31%) cases (Fig. 3a).

The fracture line in 20 (39%) of the intra-articular fractures was shown to extend anteriorly into the calca-



(a) (b)

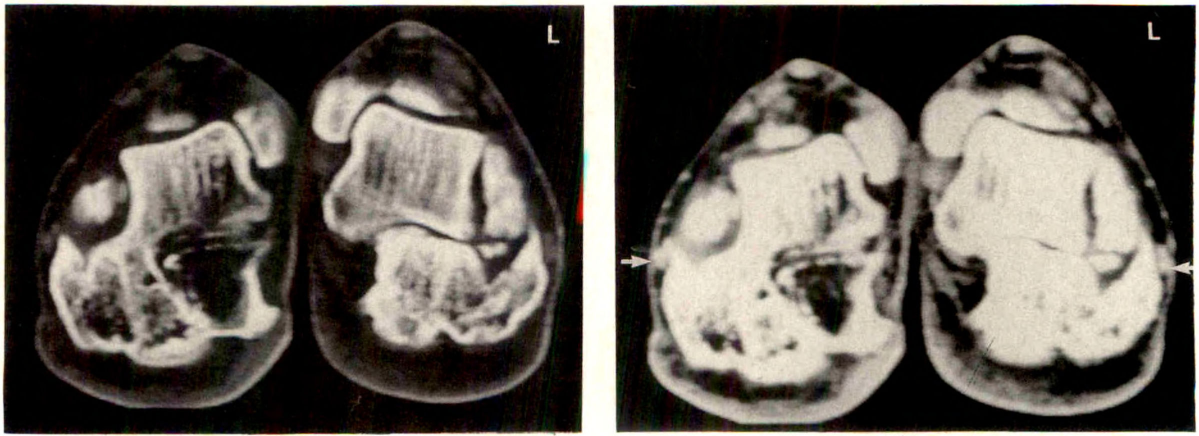
Figure 2. Coronal CT: bilateral calcaneal fractures 12 months after injury. (a) Bone window showing bilateral osteo-arthritis (OA) of the posterior subtalar joints, loose body formation and reduction of calcaneofibular space. (b) Soft tissue window showing subluxation of the peroneal tendons (1) with surrounding scar tissue on the left (2). The left flexor hallucis longus tendon is obliterated by scar tissue (3).

neocuboid joint and was only visible on the axial CT (Fig. 4). In several of the more severe examples impaction of the cuboid had caused splaying of the anterior calcaneum resulting in incongruity of the calcaneocuboid joint (Fig. 4). The articular facets of the anterior and middle subtalar joints were involved in only one and two cases respectively.

Soft tissue changes

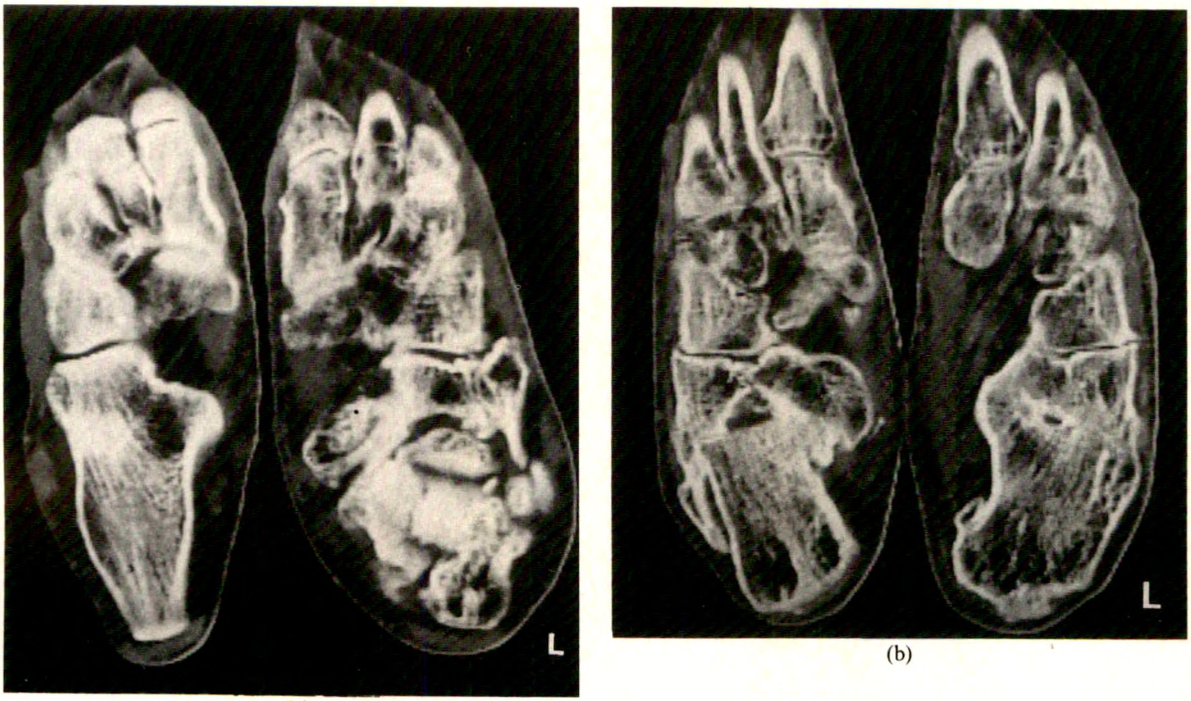
The position of the peroneal tendons was shown to be normal on coronal CT in 19 (37%) of the intra-articular fracture cases. In a further seven (13.7%) cases the position was normal but the obliteration of the surrounding fat plane by the encroachment of bone was considered to indicate entrapment of the tendon sheath (Fig. 5). Subluxation of the tendon was demonstrated in 14 (27.4%) (Fig. 2b) and dislocation in 10 (19.6%) (Fig. 3b).

Structural abnormalities of the peroneal tendons were identified in 32 (62%) cases. In 14 cases abnormal scar tissue was present adjacent to or surrounding the tendon sheath (Fig. 6a). In eight cases fluid distension of the synovial sheath producing a low density halo indicated chronic tenosynovitis (Fig. 6b). In a further eight cases there was enlargement of the tendon sheath containing heterogeneous low density areas indicating a



(a) (b)

Figure 3. Coronal CT: bilateral calcaneal fractures 5 years after injury. (a) Bone window showing severe OA of the left posterior subtalar joint with loose body formation, non-surgical ankylosis on the right and bilateral calcaneofibular abutment. (b) Soft tissue window showing bilateral dislocation of the peroneal tendons (arrowed).



(a)

(b)

Figure 4. Axial CT: Bone window. (a) Left calcaneal fracture 42 months after injury showing splaying of the calcaneum, impaction and secondary OA of the calcaneocuboid joint. (b) Bilateral calcaneal fractures 39 months after injury with calcaneal splaying and impaction of the calcaneocuboid joints.

chronic partial rupture (Fig. 6c) of the tendon. Absence of a portion of the peroneus brevis tendon owing to a complete rupture was present in two cases (Figs 7a and 7b).

Scar tissue surrounding the medial tendons was identified in five cases, affecting the flexor hallucis longus sheath in four (Fig. 2b) and the tibialis posterior in one. There was bony encroachment on the flexor hallucis longus sheath in two cases although the tendons remained normal and in one case the sheath was replaced by low density soft tissue owing to complete rupture of the tendon.

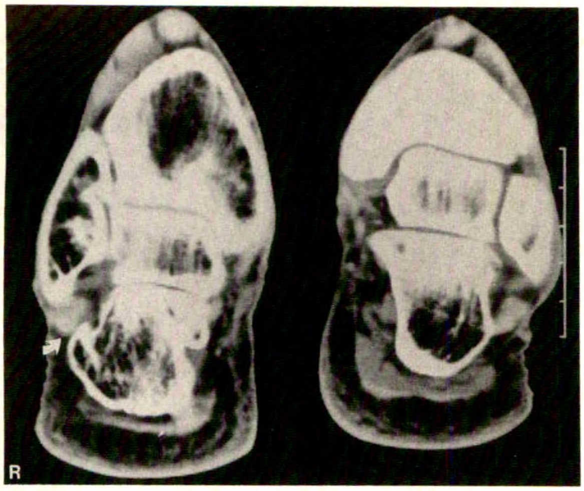


Figure 5. Coronal CT: soft tissue window. Right calcaneal fracture 3 years after injury showing entrapment of the peroneal tendons between the lateral malleolus and lateral calcaneal spur (arrowed).

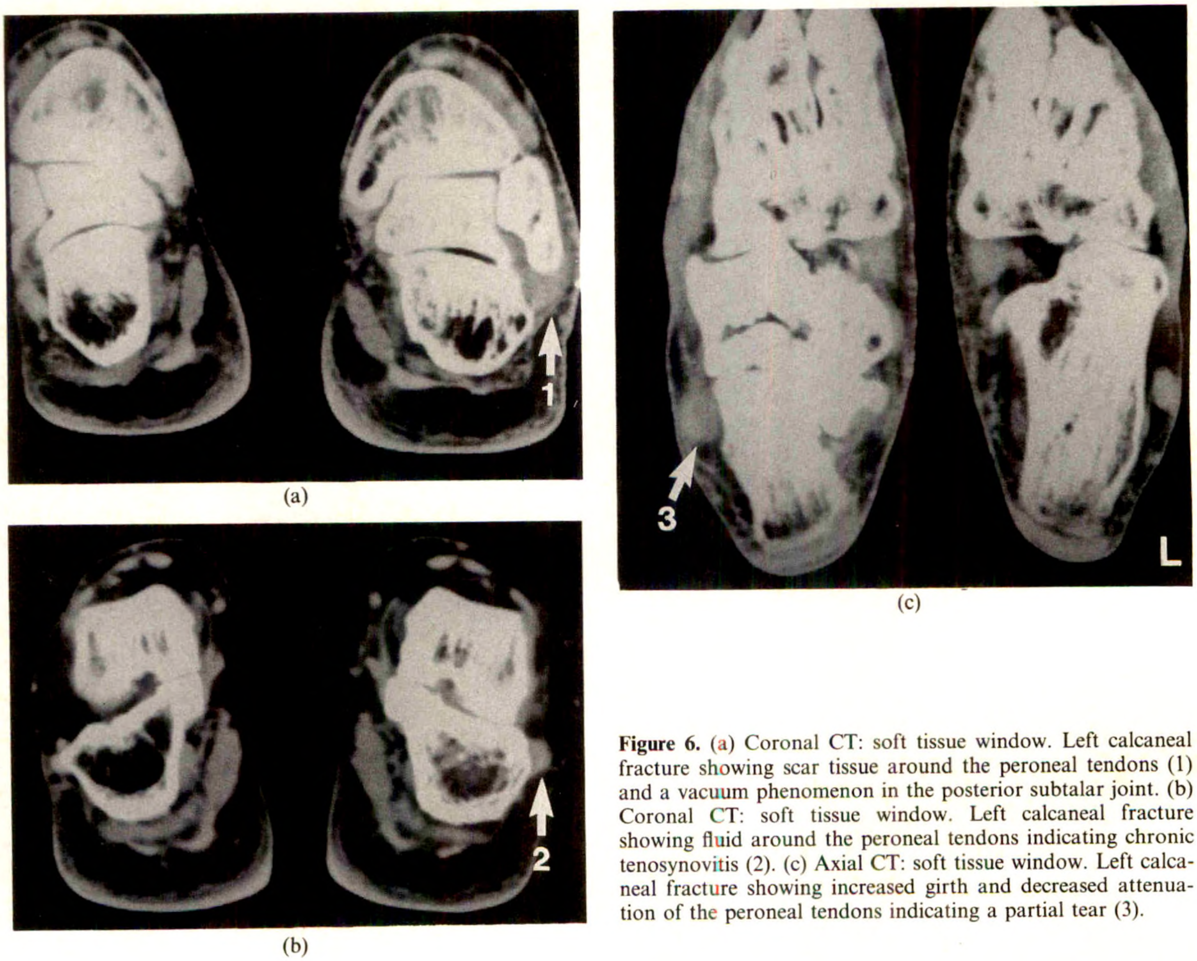
Wasting of the abductor digiti minimi muscle was evident in 16 (32%) cases (Fig. 7c).

The position of the peroneal tendons was most accurately assessed from the coronal CT but the structural changes were often easier to identify on the axial images. The appearance of the medial tendons and abductor digiti minimi muscle was best seen on the coronal images.

Disability score

The mean disability scores (MDS) (Fig. 2) for the various types of calcaneal fracture are illustrated in Fig. 8a. The more minor the fracture the lower the MDS whereas the intra-articular fracture group had the highest MDS of 3.4. For this latter group there was no relationship between the MDS and the time elapsed since the injury (Fig. 8b). The MDS for those cases with and without various abnormalities identified from the CT are shown in Fig. 8c. It should be noted that the disability score is not a true linear scale.

The MDS for the intra-articular fractures with struc-



(a)

(b)

(c)

Figure 6. (a) Coronal CT: soft tissue window. Left calcaneal fracture showing scar tissue around the peroneal tendons (1) and a vacuum phenomenon in the posterior subtalar joint. (b) Coronal CT: soft tissue window. Left calcaneal fracture showing fluid around the peroneal tendons indicating chronic tenosynovitis (2). (c) Axial CT: soft tissue window. Left calcaneal fracture showing increased girth and decreased attenuation of the peroneal tendons indicating a partial tear (3).

tural abnormalities of the peroneal tendons was 3.7. Further analysis of this group shows that those cases with CT evidence of either chronic tenosynovitis or a chronic partial tendon rupture had an MDS of 3.0 whereas those with scar tissue around the tendon sheath had an MDS of 4.9.

There was little correlation between the MDS and depression and splaying of the calcaneum and depression and reduction of the sustentacular angle from direct CT measurements.

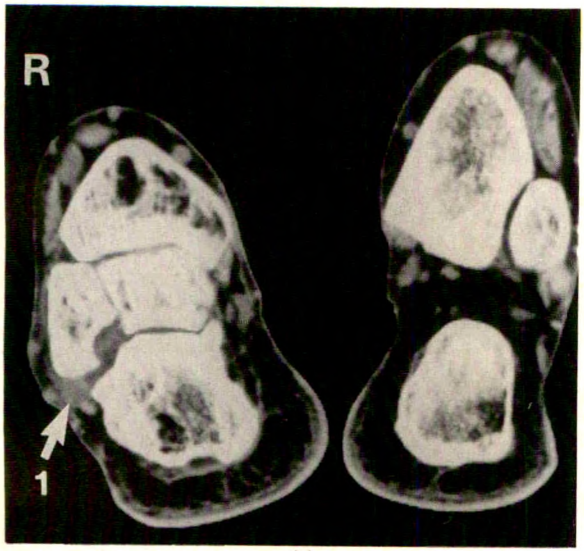
Ten of the intra-articular fracture group had undergone some form of surgery within a short time of the original injury. The MDS of the surgical group was 3.8 as opposed to 3.6 of the conservatively treated patients.

Discussion

Calcaneal fractures almost invariably occur as a result of a fall from a height. For this reason, the injury is commoner in men. In women the average age of incidence of these fractures is greater and the severity of the fall often appears relatively minor. Several of the elderly women in this study had sustained a calcaneal fracture after tripping over a single step and in this situation it is the weight of the patient and postmenopausal osteoporosis that are the more important factors.

In order to appreciate the value of CT in the assessment of acute and chronic fractures of the calcaneum it is necessary to understand the basic fracture patterns and to have a sound knowledge of the normal CT anatomy of the hindfoot (Heger & Wulff, 1985; Solomon et al, 1986; Cronier et al, 1988). CT has little place in the evaluation of extra-articular fractures of the calcaneum (Segal et al, 1985) apart from Type 3 fractures (Fig. 1) where, on occasion, it may be difficult to determine whether the fracture is truly extra-articular from the plain radiographs alone. In the acute phase coronal CT will adequately demonstrate the involvement of the posterior articular facet and calcaneal depression with calcaneofibular abutment but, without either axial CT or axial reformatting of multiple thin coronal slices, involvement of the calcaneocuboid joint will be overlooked.

It is not the purpose of this study to examine acute calcaneal fractures although the underlying fracture pattern can still be deduced from the CT months or



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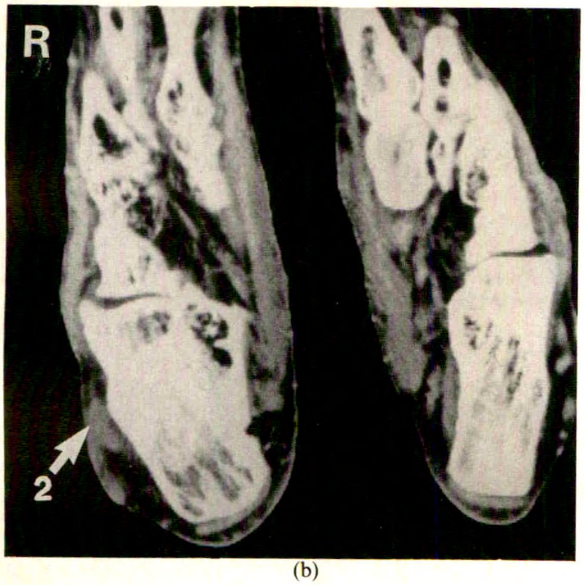

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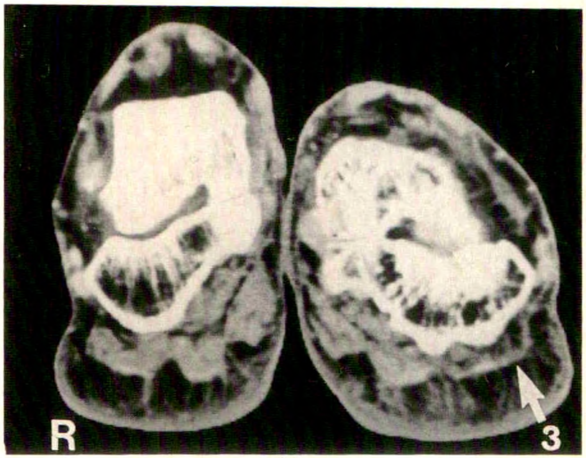

(c)

Figure 7. (a) Coronal CT: soft tissue window showing scarring adjacent to the lateral malleolus, low attenuation in the location of the peroneus brevis tendon (1) and a normal peroneus longus tendon. (b) Axial CT: soft tissue window of same case as (a) showing low attenuation just anterior to the peroneus longus tendon indicating a complete rupture of the peroneus brevis tendon (2). (c) Coronal CT: soft tissue window of left calcaneal fracture showing wasting of the abductor digiti minimi muscle (3).

years later even after healing. There are numerous reports of the value of CT in the acute phase (Guyer et al, 1985; Heger et al, 1985; Gilmer et al, 1986; Hindman et al, 1986; Rosenberg et al, 1987a; Heuchemer et al, 1988; Lowrie et al, 1988) but irrespective of whether patients undergo conservative or surgical management a significant proportion will be left with deformity and prolonged disability.

Complications of healed intra-articular calcaneal fractures which may cause persistent pain include post-traumatic osteoarthrosis of the posterior subtalar and calcaneocuboid joints, peroneal tendon and medial tendon dysfunction and various nerve compressions/entrapments (Guyer et al, 1985; Pablot et al, 1985; Zirna & Aquino, 1986). In this study of patients many months after sustaining a calcaneal fracture a crude, non-linear scale of the patients' current clinical condition was achieved using a disability score (Table II). As might be expected the more minor the fracture the lower the MDS (Fig. 8a). The presence of post-traumatic osteoarthrosis of the posterior subtalar joint (Figs 2a and 3a) and reduction or obliteration of the calcaneofibular space (Figs 2a and 3a) were both associated with a considerably higher MDS than those cases in which these features were absent (Fig. 8c). Similarly, involvement of the calcaneocuboid joint (Fig. 4), only visible on the axial CT, was also shown to be associated with a higher MDS (Fig. 8c). It is likely that these features are the direct cause of the increase in the MDS, although it is impossible to be certain, as they all occur with increasing frequency the more severe the fracture. In two cases the degree of disruption of the posterior subtalar joint resulted in ankylosis of the hindfoot (Fig. 3a).

Despite the fact that it has long been recognized that one of the major long-term complications of intra-articular calcaneal fractures is injury to the peroneal tendons (Palmer, 1948; Essex-Lopresti, 1952) it is only relatively recently that CT has been applied to the identification of the position and structural changes of these and other tendons around the ankle and hindfoot (Rosenberg et al, 1986, 1987b, 1988a,b,c). Peroneal tendon injury may be inferred by lateral broadening of the calcaneum on plain radiographs or CT. Precise demonstration of the peroneal tendons requires the CT to be viewed on a soft tissue window setting. The alternative imaging techniques of peroneal tenography

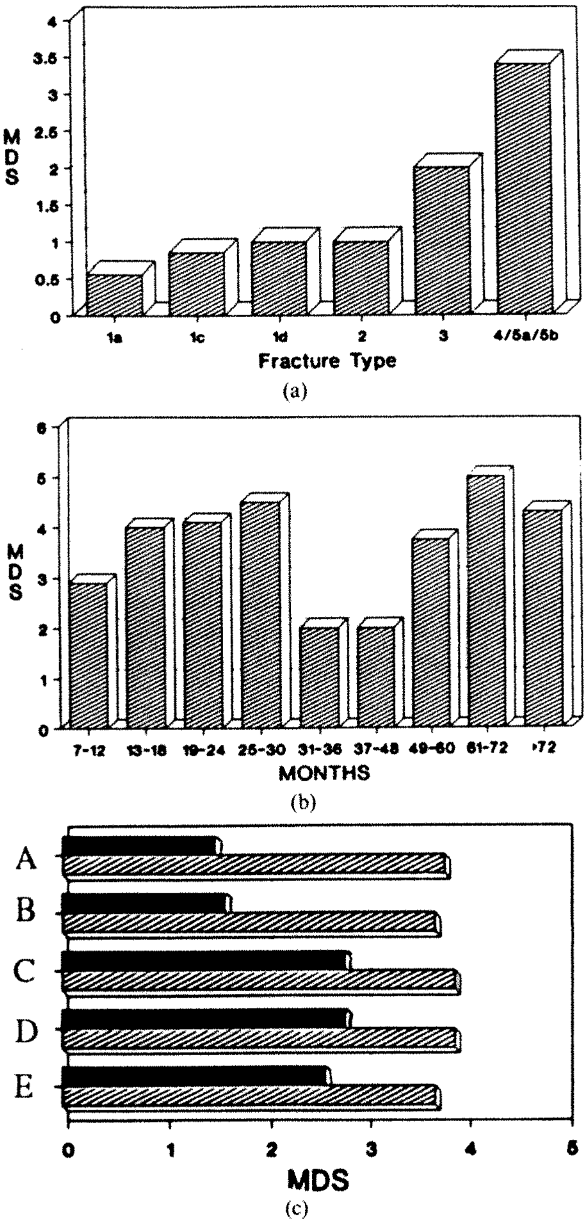

Figure 8. (a) Mean disability score by type of calcaneal fracture. (b) Mean disability score by time since injury for the intra-articular fractures. (c) CT findings by mean disability score for the intra-articular fractures (■, abnormality absent; ▨, abnormality present). A = osteoarthritis; B = reduced/obliterated calcaneofibular space; C = fracture involving calcaneocuboid joint; D = subluxed/dislocated peroneal tendons; E = structural abnormality of peroneal tendons.

or magnetic resonance imaging will both reveal abnormalities of the peroneal tendons but the former is invasive and the latter expensive and not universally available.

Subluxation or dislocation of the peroneal tendons (Figs 2b and 3b) was shown to be associated with a higher MDS than in those patients with no displacement (Fig. 8c). This feature is commoner the more severe the fracture. Of particular interest was the fact that, in those cases with normally located peroneal tendons, obliteration of the surrounding fat plane by encroachment of the adjacent bone, thereby indicating entrapment (Fig. 5), was not associated with a higher MDS in comparison with those with a normal calcaneofibular distance, provided that there was no concommitant structural abnormality of the tendon itself. Therefore in a patient with chronic pain, a trapped but otherwise normal looking peroneal tendon may not be the cause of the persistent symptoms.

Of greater significance than the location is the structural appearance of the peroneal tendons. CT has been shown to be accurate when correlated with surgical findings (Rosenberg et al, 1987b, 1988b,c). This study confirms the high incidence of abnormalities of the peroneal tendons following intra-articular fractures (Rosenberg et al, 1987b) even months and years after the original injury. Using criteria described by Rosenberg (Rosenberg et al, 1988a) 63% of the intra-articular fracture group in this series were shown to have structural abnormalities of the peroneal tendons. Four categories of abnormality were identified: chronic tenosynovitis (Fig. 6b), scarring or post-traumatic stenosing tenosynovitis (Figs 2b and 6a), chronic partial rupture (Fig. 6c) and complete rupture of the tendon (Fig. 7). Overall these categories were associated with a higher MDS. Scarring or post-traumatic stenosing tenosynovitis was a more significant finding than either chronic tenosynovitis or chronic partial rupture. The highest MDS of 5 in this category was found in the presence of complete rupture of the peroneus brevis tendon (Fig. 7) but was present in only two cases. Similar abnormalities were identified affecting the medial tendons of the hindfoot, but because of the relatively small number involved and the coexistence in these cases of other bone and soft tissue changes, the influence of these abnormalities on the patients' respective disability scores is uncertain.

The site of the plantar nerves medially and the sural nerve posterolaterally can be demonstrated on CT (Solomon et al, 1986) but because of their small size precise localization is difficult. Nevertheless possible nerve damage may be inferred when marked splaying of the calcaneal fracture obliterates the normal fat planes at the site of one or other nerves. Injury to the lateral plantar nerve could be responsible for the wasting of the abductor digiti minimi muscle, a previously unreported CT finding, seen in almost one third of the intra-articular fracture group (Fig. 7c). An alternative explanation for this appearance could be that comminution of the fracture resulted in disruption of the origin of the muscle from the lateral and medial processes of the calcaneal tuberosity.

The degree of disability being proportional to the severity of depression and comminution of the calcaneal fracture is a familiar concept. In this study, however, there was little correlation between the MDS and direct

CT measurements of calcaneal depression, splaying and alterations of the sustentacular angle. Failure to confirm this relationship may be due in part to the crude nature of the clinical assessment or to bias in patient selection. It is likely that the majority of the two thirds of the original 188 patients who declined to participate in this study did so because they were symptom free. Many of those who did attend for the CT examination were undoubtedly motivated by persistent symptoms and therefore the results of the study should not be considered representative of the entire population of patients sustaining a calcaneal fracture.

The fact that the MDS was higher in the group who had undergone some form of surgery than in those treated conservatively is more likely to be due to the severity of the fracture and not a reflection of the nature of the operation. Prolonged disability remains all too common after intra-articular calcaneal fractures irrespective of the mode of treatment. In these patients CT of the hindfoot allows accurate assessment of bone and soft tissue abnormalities prior to any remedial surgery. CT measurements of calcaneal deformity may be of value when comparing the results of operative correction (Frahm et al, 1989).

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Real-time digital contrast enhancement and magnification in the assessment of scaphoid and other wrist injuries

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Abstract. A study on the value of a commercially available desk-top digital magnifier–contrast enhancer (DETECT System) was made in a series of 550 patients presenting with an acute wrist injury. Four radiologists, of varying experience, independently reviewed the radiographs on a conventional lightbox and later with the digitizer. In the scaphoid series (350 cases), the performance of the two more experienced radiologists was marginally better with the digitizer, whereas the less experienced radiologists performed slightly worse. Overall the digitizer improved the confidence of the radiologists in diagnosing correctly the presence of a scaphoid fracture but, for the less experienced radiologists, this was at the expense of identifying normality. In the wrist series (200 cases), the use of the digitizer resulted in a minor increase in the true positive and decrease in the false negative observations, but this was offset by a concomitant minor increase in the false positive and decrease in the true negative categories. Evaluation of the soft-tissue planes around the wrist joint showed a limited value in the identification of a scaphoid fracture with an overall positive predictive value of 0.26. Correlation of soft-tissue changes and the presence or absence of a scaphoid fracture was slightly worse with the digitizer. Possible causes for the apparently poorer performance of the digitizer are discussed, as well as the relative merits and potential value of the unit.

The failure to identify a scaphoid fracture correctly remains a common cause for litigation in medicine (Craig, 1989). In addition to plain radiography, other imaging modalities have been advocated as an aid to diagnosis, including scintigraphy (Stordahl et al, 1984; Wilson et al, 1986), ultrasound (Bedford et al, 1982; Shenouda & England, 1987) and thermography (Hosie et al, 1987). None has stood the test of time because of the considerable resources and cost necessary to perform the examinations as well as doubt concerning their efficacy (Da Cruz et al, 1988). Digital radiography allows the operator to manipulate the image but the majority of current systems are extremely expensive and entail major changes to the X-ray department. The purpose of this paper is to assess the value of a desk-top unit, which can magnify and digitize conventional radiographs in real-time, in a series of patients presenting with acute wrist trauma.

Patients and methods

The radiographs of 550 patients presenting to the Accident & Emergency Department of the Birmingham General Hospital with an acute wrist injury were reviewed. Of these 350 cases, suspected of having a possible scaphoid injury, had undergone scaphoid views (postero-anterior (PA), PA oblique, PA with 30° angulation towards the elbow and lateral) of the wrist (Scaphoid series), and in the remaining 200 patients, antero-posterior and lateral radiographs of the wrist had been obtained (Wrist series). Apart from ensuring that there were adequate numbers of patients in each series and that the presenting complaint had been acute trauma, no further criteria for patient selection were applied. The correct diagnosis was ascertained in all cases by a radiologist reviewing both the initial and follow-up radiographs.

Four radiologists with 2, 3, 5 and 9 years' radiological experience assessed the initial radiographic examination of each case on a conventional light box with the addition of a "bright-light" and magnifying glass as required. Each radiologist recorded observations regarding the presence or absence of a fracture as follows: definite normal, equivocal normal, equivocal abnormal or definite fracture.

At a later date the same four radiologists assessed the same radiographs, unaware of the details of their original observations, using a digital processor. The digitizing unit, the DETECT System (Damon Corporation, Massachusetts), consists of a horizontal light-box viewed by a high resolution video camera with either a ×5 or ×10 zoom lens. The camera transmits an electronic image of the X-ray film to a computer which digitizes and processes the image. The processed image is displayed on a television monitor in a 525×480 matrix with a dynamic range of over 2000 grey levels and a resolution of better than 100 microns. A real-time display is achieved by a screen refresh rate of 30 times per second (Wetzner & Newberg, 1988). As well as being able to zoom to an area of interest, the operator can view the image in either positive or negative modes and, using a joystick, the degree of contrast enhancement can be instantly altered to suit the individual preference of the viewing radiologists (Fig. 1).

A further radiologist viewed the scaphoid series, with and without the digitizer, to assess the soft tissues. The appearances of the scaphoid, dorsal and pronator fat planes were recorded. Initial attempts to assess pararadial and para-ulnar swelling were abandoned, as these

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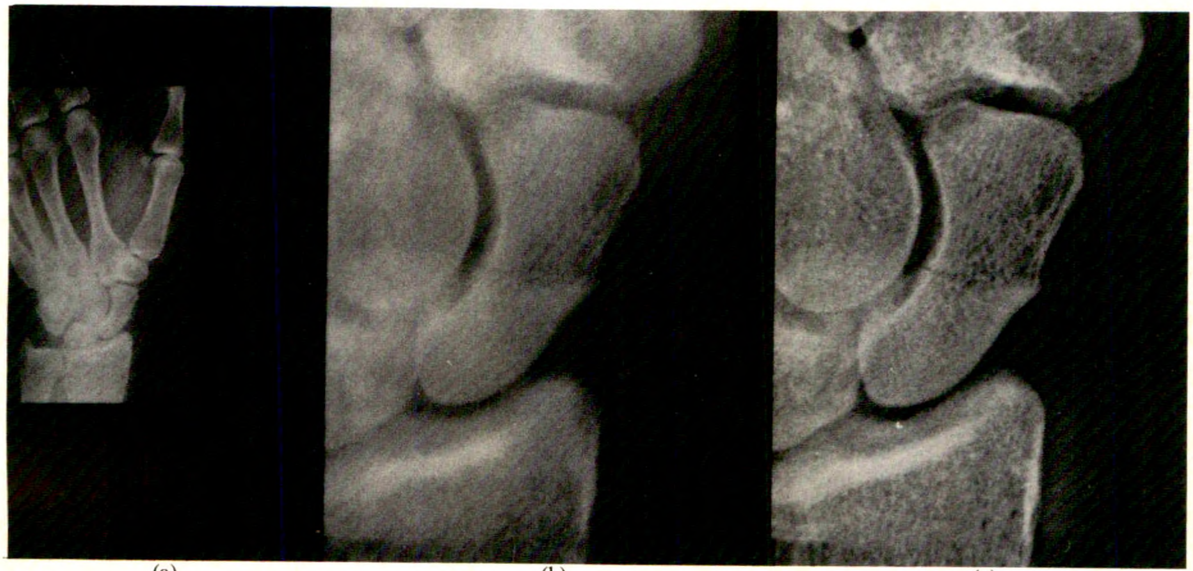


Figure 1. Postero-anterior projection of a subtle fracture waist of scaphoid. (a) Unenhanced/unmagnified image. (b) Unenhanced magnification (× 5) relative to (a). (c) Contrast enhanced magnification (× 5) relative to (a).

areas were often incompletely demonstrated due to scrupulous coning of the X-ray beam.

Statistical analysis was performed separately on the scaphoid and wrist groups to ascertain the performance of each radiologist with and without the digitizer.

Results

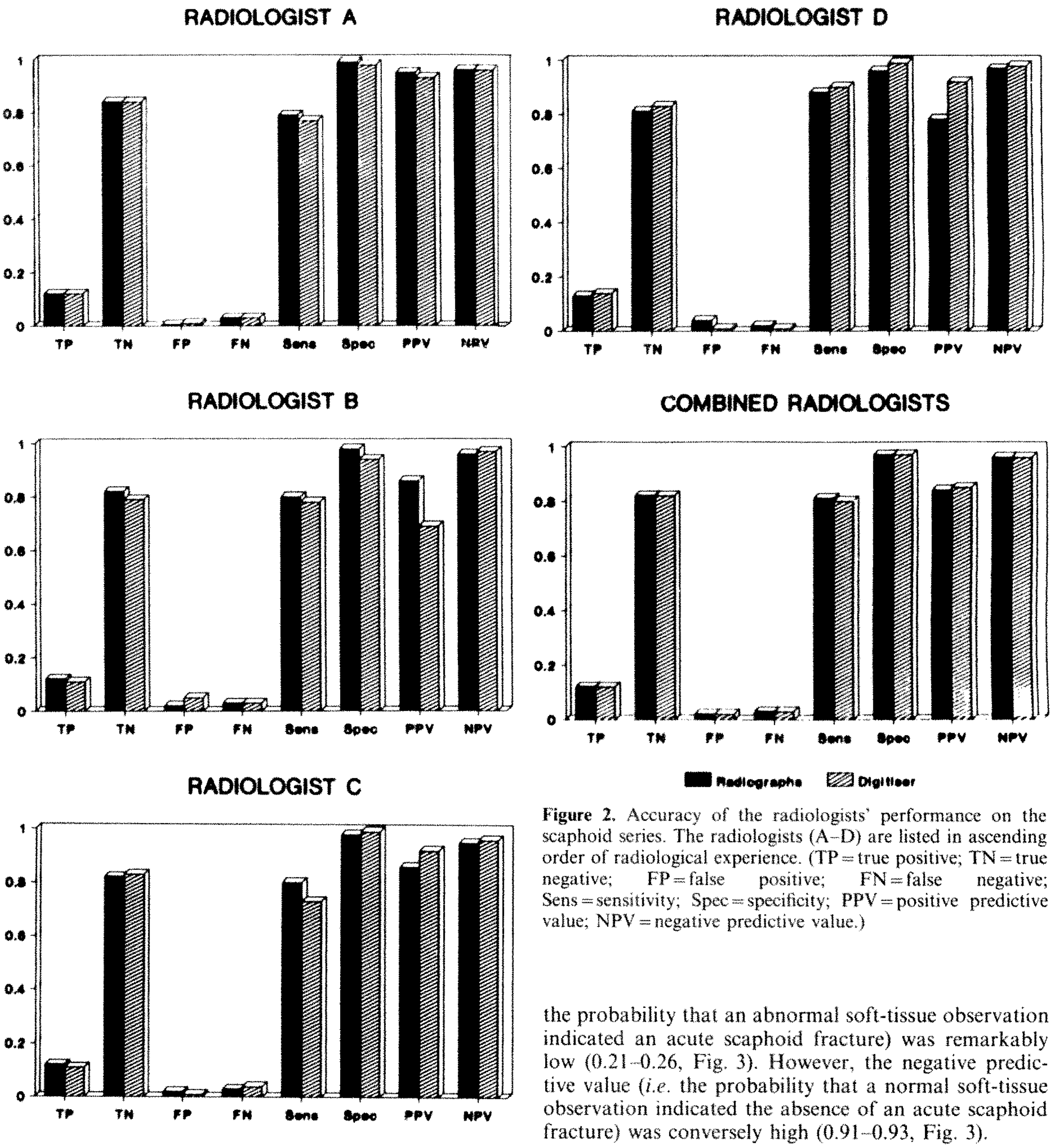
Scaphoid series

In the group of 350 patients there were 52 scaphoid fractures (38 waist of scaphoid, two proximal pole and 12 distal pole) (Fig. 1), nine of which were chronic fractures predating the current episode of trauma. There were nine flake fractures from the dorsum of the triquetrum and 36 fractures of the distal forearm bones, three-quarters of which were undisplaced fractures of the distal radius.

The test outcome for each individual radiologist and the combined group based on the actual presence or absence of a scaphoid fracture and the radiologist's report are summarized in Fig. 2. For this purpose the two "normal" observations, equivocal and definite, were combined to give a single normal category. The definite fracture and equivocal abnormal observations were similarly added together to give a single fracture category. No significant differences were evident in the overall accuracy in the performance of any of the radiologists with or without the digitizer. The two with more radiological experience (Radiologists C and D) were marginally more accurate with the digitizer, unlike the two less experienced radiologists (A & B), who performed slightly worse with the unit (Fig. 2). However, the true positive, true negative, false positive, false negative, sensitivity, specificity, positive and negative predictive values for the combined results were virtually identical (Fig. 2).

Although no significant differences were evident when considering the test outcome as a straightforward positive or negative result, minor changes were apparent when the definite observations were differentiated from the equivocal. All four radiologists identified a higher proportion of true scaphoid fractures as definite fractures with the digitizer than from the radiographs alone. The digitizer improved the definite true positive pick up rate by a mean of 8.7% (range 4.7–11.6%). This was matched in the results of the two more experienced radiologists by a mean improvement in the identification of definite normal/true negative cases of 2.8%. The other two radiologists exhibited a mean deterioration in the identification of definite normal/true negative cases of 2.1%. Receiver operator characteristic curves were not considered to be useful to illustrate this point, because of the extremely high specificity of the test.

The soft tissues around the wrist joint in terms of the scaphoid, dorsal and pronator fat stripes were classified as normal, bowed, indistinct or obliterated. Analysis of the results from the plain radiographs showed a statistically significant association between the total abnormal observations of the respective fat planes and the presence of an acute scaphoid fracture ($p > 0.001$). Although the association was still statistically significant when the films were scrutinized with the digitizer, the degree of the significance was reduced ($p > 0.01$). Figure 3 summarizes the proportion of cases, excluding non-scaphoid fractures, observed to have normal or abnormal soft tissues against the test outcome when viewing the radiographs alone and then with the digi-


RADIOLOGIST A

RADIOLOGIST D

RADIOLOGIST B

COMBINED RADIOLOGISTS

RADIOLOGIST C

Figure 2. Accuracy of the radiologists' performance on the scaphoid series. The radiologists (A–D) are listed in ascending order of radiological experience. (TP = true positive; TN = true negative; FP = false positive; FN = false negative; Sens = sensitivity; Spec = specificity; PPV = positive predictive value; NPV = negative predictive value.)

tizer. The category of abnormal soft tissue used in Fig. 3 is the sum of the various results regarding each respective fat plane, *i.e.* the total observations of the bowed, indistinct or obliterated fat planes. For the purpose of this study, the classification of soft-tissue abnormalities was mutually exclusive with the observer recording only the most prominent feature. None of the individual categories was able to distinguish between the presence or absence of an acute scaphoid fracture more accurately than any other. The positive predictive value (*i.e.* the probability that an abnormal soft-tissue observation indicated an acute scaphoid fracture) was remarkably low (0.21–0.26, Fig. 3). However, the negative predictive value (*i.e.* the probability that a normal soft-tissue observation indicated the absence of an acute scaphoid fracture) was conversely high (0.91–0.93, Fig. 3).

Wrist series

In the group of 200 patients, fractures of the distal radius were identified in 78 patients, of which 44 were Colles fractures. A further nine cases were shown to have a carpal fracture (five flake fractures of the triquetrum, three scaphoid, one hamate fracture and a dislocated lunate bone).

For forearm fractures there was a minor increase in the false negative observations (0.007 to 0.017) with the digitizer whilst the remaining true positive, true negative and false positive categories were virtually identical. For

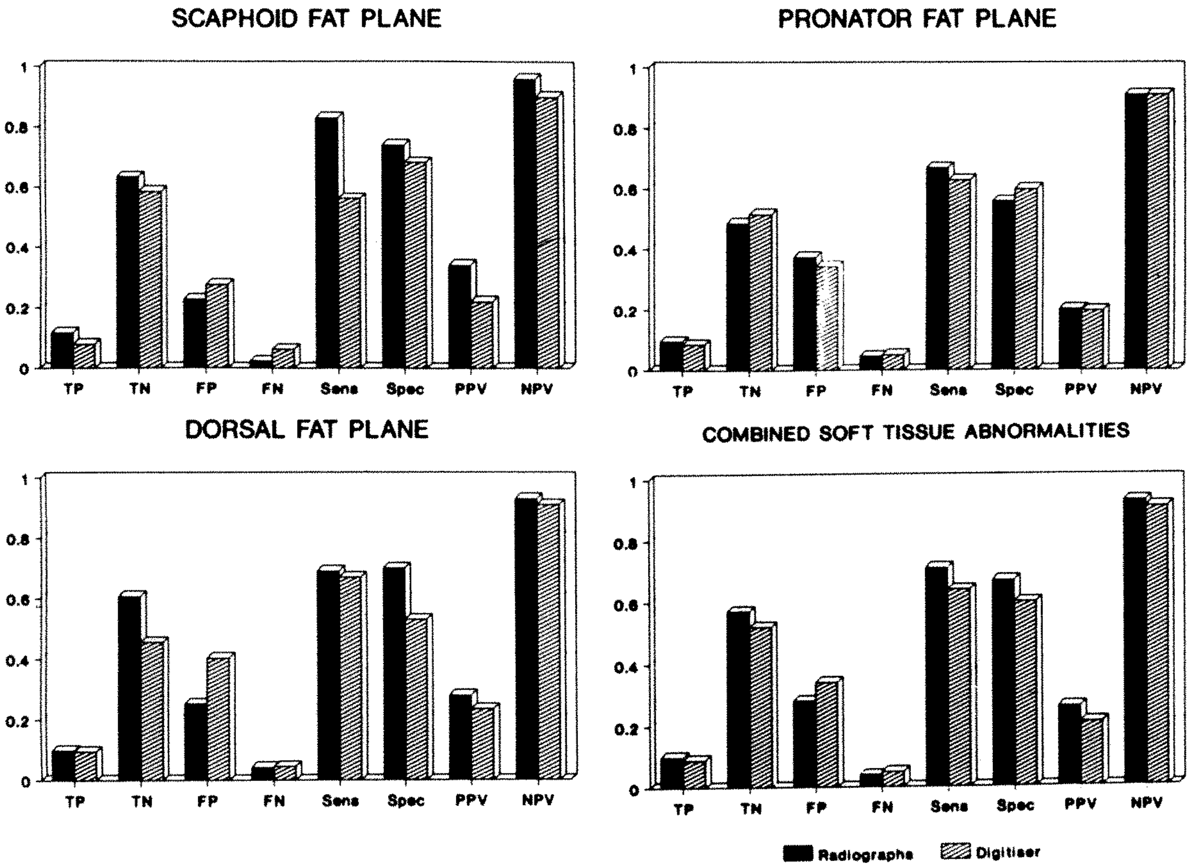


Figure 3. Correlation of the observations from the scaphoid series of abnormal soft-tissue planes around the wrist joint and the presence/absence of an acute scaphoid fracture. All cases with non-scaphoid fractures have been excluded from this analysis. (Key as for Fig. 3.)

the few carpal fractures identified in the wrist series, the digitizer showed a minor improvement in the true positive and false negative observations, but also a minor deterioration in the false positive and true negative observations.

Discussion

Despite the fact that, over the past 15 years, image acquisition in computed tomography, magnetic resonance, nuclear medicine, ultrasound and digital vascular imaging has been by digitization, the development of digital imaging in conventional radiography has lagged behind (Fraser et al, 1989). The logistics of installing a picture archiving and communications system (PACS) in an existing department are enormous and the high cost alone has proved sufficient to deter all but the wealthiest institutions. As yet, no manufacturer has installed a complete, functioning, PACS network (Dawood et al, 1989).

Irrespective of the expense, the success or failure of a digital system ultimately depends on the image quality. In order to provide diagnostic image quality comparable to that of conventional radiographs, there is a minimum spatial resolution requirement which is related to the matrix and pixel size. Recent studies have shown that, by altering the spatial resolution, the diagnostic image quality of several PACS systems is either comparable to or poorer than the plain radiographs in the assessment of fine lung (Fajardo et al, 1989; Hayrapetian et al, 1989; Shelline et al, 1989) or bone detail (Bramble et al, 1989; Dawood et al, 1989; Murphey, 1989).

The digitizing unit used in this study does not have many of the disadvantages of a PACS system. It is relatively cheap, compact and therefore easily moved and does not require an interface with any existing equipment in the X-ray department. It enables the radiologist to interrogate the radiograph instantaneously (*i.e.* in real-time) by magnification and contrast enhancement (Fig. 1). The inherent ability of the unit to magnify the image prior to digitization improves the resolution but, unlike the theoretically optimal PACS system, it does not eliminate the need for conventional film, although retention of the latter can be helpful for medicolegal purposes.

Although it is well recognized that scaphoid fractures may not be radiographically visible at presentation, this study confirms that the initial plain radiograph remains a remarkably accurate test for detecting these fractures in terms of sensitivity and specificity (Fig. 2). The two more experienced radiologists performed marginally better with the digitizer, unlike the two less experienced, who performed worse. This differs from the experience of the unit when used for mammography, where it is considered of greatest value in training the novice mammographer. One possible explanation in bone work is that the ability to magnify by a factor of 10 tends to accentuate anatomical features that would otherwise remain subtle, and that the more knowledgeable radiologist should be able to distinguish a fracture line from normal clefts, ghosts of growth plates, nutrient channels etc. (Keats, 1988). This is borne out by the fact that, differentiating between definite and equivocal observations, this study shows that the digitizer improves the confidence of the radiologist in correctly diagnosing the presence of a scaphoid fracture but, for the less experienced radiologist, this was at the expense of accuracy in identifying normality.

The importance of routinely evaluating the soft tissues to detect occult fractures in wrist trauma is well recognized (Terry & Ramin, 1975; Curtis et al, 1984; Carver & Barrington, 1985; Zammit-Maempel et al, 1988). In particular, displacement or obliteration of the scaphoid fat plane (navicular fat plane in the American literature), which is formed by the radiolucent common tendon sheath of the extensor pollicis brevis and adductor pollicis longus muscles (Corfitsen et al, 1989), may indicate the presence of a subtle scaphoid fracture (Terry & Ramin, 1975; Cetti & Christensen, 1982). However, from analysis of the plain radiographs in this study (Fig. 3), 16% of the acute scaphoid fractures were associated with a normal scaphoid fat plane and 26% of the cases without a fracture exhibited an abnormal scaphoid fat plane. With the digitizer, 44% of the acute scaphoid fractures were said to have a normal scaphoid fat plane (Fig. 3). The apparent loss of "accuracy" with the digitizer is likely to be due to the combination of magnification and contrast enhancement accentuating the fat plane thereby altering an indistinct or obliterated observation to a normal one. It may therefore prove necessary to alter one's perception of what constitutes normality when using the digitizer in this context. We agree with the conclusion of a recent study stating that soft-tissue swelling may bring to light subtle scaphoid fractures, and its absence does not necessarily exclude a fracture, with a negative predictive value in our study of over 0.9 (Zammit-Maempel et al, 1988). However, our low positive predictive value of around 0.2 does suggest that this sign is an unreliable indicator of a scaphoid fracture (Schunk et al, 1989).

It is important not to be too dogmatic in interpreting the comparative results of this study as the process of information transfer from the image to the observer is poorly understood. The radiologists involved were unfamiliar with this form of technology. Undoubtedly, as the study progressed, they became more proficient in the use of the digitizer. Would prolonged use have resulted in increased accuracy?

A computational model, attempting to predict the performance of observers, suggests that an image is detected by first composing a "primal sketch" of the fundamental properties of the picture (shape, distance, orientation, etc.) followed by a more thorough analysis to confirm or refute the initial impression (Hendee, 1989). While the digitizer may prove suitable for the in-depth interrogation of the image, most radiologists will find it easier to make the critical initial assessment using a conventional light box.

The detection of visual signals should be distinguished from cognitive interpretation of those signals (Hendee, 1989). Detection of the visual information occurs rapidly, whereas cognition takes longer and requires perceptual knowledge. Digital radiography reveals the image to most radiologists in an unfamiliar form, and it will therefore take time for the necessary reporting skills to develop.

Conclusion

This study shows that, in a series of patients presenting with acute wrist trauma, there is no significant difference in the overall rate of identification of scaphoid fractures when the radiographs are observed alone or viewed with a desk-top contrast enhancer and magnifier. Further studies will be necessary to see whether the digitizer may be of value at other sites where potentially occult fractures may occur.

Acknowledgments

We are grateful to Mrs E. M. Davies for performing the statistical analysis, Mrs D. Gregory for extracting films, Drs P. N. M. Tyrrell and J. F. Leahy for collecting data and Draeger Ltd, Hemel Hempstead, for the loan of the DETECT System.

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The prognostic significance of radiologically detected knee joint effusions in the absence of associated fracture

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Abstract. The significance of radiologically detected knee joint effusion as a marker of soft tissue injury following trauma is uncertain. In this study 100 patients presenting to the casualty department following acute injury, with effusions but no fracture, were assessed. Of those available for follow-up, 20% required further investigation and 11% proceeded to surgery for significant soft tissue injury. It is concluded that radiologically detected knee joint effusions are a useful marker for underlying soft tissue injury.

The radiographic signs of knee joint effusion include loss of the sharp outline of the quadriceps tendon, displacement of tendons, fat planes or sesamoid bones and gross widening of the joint space. The diagnosis of an effusion is usually made on the lateral projection and the accuracy of radiological criteria in this diagnosis has been assessed in a number of studies. The fat pad separation sign (widening of the suprapatellar stripe) is the most accurate indicator of fluid, with an accuracy of 88% in the diagnosis and 90% in the exclusion of joint effusions (Hall, 1975). Effusions as small as 1–2 ml were recognized using this sign, taking widening of the suprapatellar fat pad greater than 5 mm as significant. In an experimental study, however, 2 mm has been quoted as the normal thickness for the suprapatellar stripe (Butt et al, 1983). Sensitivity for detection of effusions is greater for overhead (vertical beam) lateral knee views than for cross-table views (Singer et al, 1985). Excessive knee flexion and poor alignment of the femoral condyles have been found to obscure the soft tissues at the base of the suprapatellar area, and ideally exposures should be made with minimal knee flexion (Hall, 1975).

The fact that a post-traumatic effusion is associated with an increase in the time required for full recovery has been recognized for the elbow joint (Smith & Lee, 1978/1979) but not previously documented for the knee. The present study was prompted by uncertainty concerning the significance of radiographically diagnosed knee joint effusions as indicators of significant soft tissue damage in patients presenting to the accident and emergency department with acute knee injuries.

Method

Over a period of approximately 4 months, 100 consecutive patients presenting acutely to the accident and emergency department with radiologically detected knee joint effusions, but no associated bony injury, were followed up. The age range was 13–90 years, with a mean of 32 years, and a male preponderance (male-to-female ratio 75:25). The mechanism of injury was diverse, but the majority of cases were due to twisting weight bearing injuries (37%), falls (23%) or direct blows (20%). The principal presenting complaints were pain and swelling. The radiographic projections obtained routinely were antero-posterior and true lateral views of the symptomatic joint, both using a vertical beam, with minimal flexion of the joint. The films were assessed for widening of the suprapatellar stripe, more than 5 mm being taken as evidence of a joint effusion. Some patients were followed up in

Table I. Outcome of patients with radiologically detected knee joint effusions without associated bony injury

	Number of cases	Percentage
Complete resolution of symptoms within 6 weeks of injury	46	58
Persisting symptoms (*e.g.* locking, pain, swelling), in excess of 6 weeks, but not sufficient to require further treatment or investigation	11	14
Persisting severe symptoms, requiring further investigation and/or prolonged medical treatment or physiotherapy	9	11
Persisting severe symptoms, requiring immobilization of knee	4	5
Meniscal tears treated by meniscectomy	8	10
Meniscal damage not amenable to surgery	1	1
Loose bodies removed	1	1
Total	80	100

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casualty review clinics, and some in orthopaedic outpatient clinics. The majority had no clinical follow-up, and were contacted by a postal questionnaire designed to assess the nature, duration, severity and possible recurrence of symptoms related to the initial injury, 4–6 months following attendance. It was possible to obtain follow-up information in 80 out of the 100 patients. The mean age of the patients available for follow-up was 33 years, similar to that of the whole group, and the male-to-female ratio was again similar at 62:18. Of the 20% of patients unavailable for follow-up, 11% had failed to respond to the questionnaire and some patients had moved without leaving a forwarding address.

Results

According to information obtained from hospital inpatient or outpatient attendance and from the postal questionnaire, patients were divided into groups as shown in Table I.

Discussion

The proportion of patients undergoing further investigation of their knee complaints is high largely because of their symptoms and also to the local enthusiasm of orthopaedic surgeons to request arthrography, etc. In this study 28% of patients followed up required treatment at hospital, 20% requiring further investigation (usually arthrography), and 11% proceeded to surgery. It is concluded that the presence of a radiologically detectable knee joint effusion following acute trauma, even without associated fracture, is a useful marker of significant underlying soft tissue damage.

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Ultrasonic morphology of the uterus and ovaries after treatment of invasive mole and gestational choriocarcinoma

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Abstract. Ultrasound imaging of the uterus and ovaries was performed on 41 patients after completion of apparently successful cytotoxic chemotherapy for invasive mole and choriocarcinoma. Uterine volume was calculated and the echopattern of the uterus and ovaries assessed. Forty-nine per cent of subjects had an abnormal uterine appearance and 20% had ovarian theca-lutein cysts. Two patients relapsed on follow-up but no predictive ultrasonic features could be established on uterine or ovarian morphology after chemotherapy.

Hydatidiform mole is an abnormal product of conception and has an incidence of approximately once for every 1500 pregnancies in the UK (Bagshawe, 1969). Molar tissue remaining after evacuation of the uterus usually spontaneously resolves. However, in 8% of cases this does not occur and the remaining trophoblastic tumour develops into invasive mole or the highly malignant choriocarcinoma (Bagshawe et al, 1986). Beta-human chorionic gonadotrophin (B-HCG) is produced by trophoblastic tissue and can be used as a sensitive marker in the follow-up after molar pregnancy so that these sequelae can be detected at an early stage (Bagshawe et al, 1973). With current cytotoxic drugs, the great majority of patients with invasive mole or choriocarcinoma can be cured (Newlands et al, 1986). However, a small proportion of cases do relapse after apparently successful chemotherapy. These again can be detected by the use of B-HCG follow-up.

Ultrasound is a modality that has been applied to the diagnosis of hydatidiform mole (MacVicar & Donald, 1963; Gottesfield et al, 1967; Leopold, 1971). Woo et al (1985) suggested that ultrasound could be used in monitoring cases of invasive mole and choriocarcinoma as a guide to the need for further treatment or hysterectomy. However, the appearances of the uterus after the cytotoxic chemotherapy of gestational trophoblastic tumours have not been clearly documented. This is an important area because residual abnormalities of the uterus after therapy may be misinterpreted as persistent tumour resulting in an unnecessary prolongation of toxic chemotherapy. This study describes the appearances of the uterus and ovaries after apparently successful therapy of invasive mole and gestational choriocarcinoma, and correlates the findings with relapse of the disease.

Patients and methods

The Charing Cross Hospital is the main referral centre for the treatment of gestational trophoblastic tumours in the UK. Forty-one patients referred with invasive mole or choriocarcinoma were assessed prospectively at the end of the last course of cytotoxic treatment using a single real time ultrasound of the pelvis. A Diasonics DRF 400 ultrasound scanner was used and all the scans were performed by the same author (M.G.L.) but were also assessed by J.E.B. The uterus was systematically examined in several longitudinal and transverse planes. Measurements were taken so that the uterine volume could be calculated using the prolate ellipsoid formula:

$$\text{volume (ml)} = AP \times W \times L \times 0.523$$

where AP is the maximum antero-posterior diameter, W is the maximum width and L the length of the uterus measured in cm. A value of 120 ml was taken to be the upper limit of a normal uterus (Requard & Mettler, 1980). The echo pattern of the uterus was carefully examined and classified as follows:

normal;
hypoechogenic;
hyperechogenic;
mixed echogenicity;
or containing transonic areas.

The presence of ovarian cysts was recorded. Details of treatment and B-HCG values were obtained from the patients' computerized files of the Department of Medical Oncology. In all cases, serum B-HCG values were normal (< 4 iu/l) at the time of the ultrasound scan. Follow-up of the patients in the study has been for a minimum of 1 year.

Results

Statistical analysis was performed using the χ^2 test with Yates' correction.

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Table I. Ultrasonic findings of uterine volume and echopattern in 41 patients with gestational trophoblastic tumours

		Uterine echopattern		
		Normal	Abnormal	Total
Uterine volume (ml)	< 120	20	9	29
	> 120	1	11	12
Total		21	20	41

Uterine volume and echopattern (Table I)

Twenty-nine patients (70%) had a normal uterine volume at the end of chemotherapy. The mean volume in this group was 85 ml (SD 20) with a range of 50 ml to 120 ml. Twenty of these patients (69%) also had normal ultrasonic uterine appearances. Of the remaining nine subjects with abnormal uterine features, three had a mixed echo pattern (Fig. 1), two had transonic areas (Fig. 2) and four had both mixed echogenicity and transonic areas (Fig. 3).

Twelve subjects had a raised uterine volume with a mean of 175 ml (SD 55) and a range 135 ml to 330 ml. This was associated with a normal uterine appearance in only one case. Six patients had mixed echogenicity, four had a mixed pattern with transonic areas and one had transonic areas alone.

Overall, 21 patients (51%) had ultrasonically normal morphology of the uterus at the end of treatment. Of these, all but one were associated with a normal uterine volume.

Ovarian cysts

Eight patients (20%) had ovarian cysts at the end of treatment (Fig. 4). Six had unilateral cysts and two had

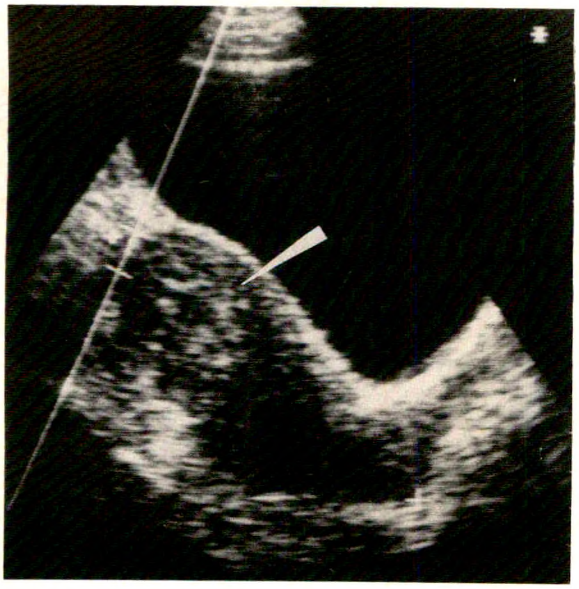

Figure 1. Longitudinal section in the midline of the uterus showing a mixed echopattern (arrowhead).

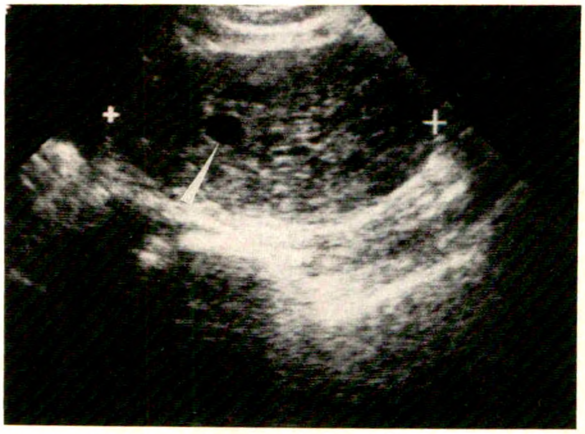

Figure 2. Transverse section of the body of the uterus demonstrating transonic areas (arrowhead).

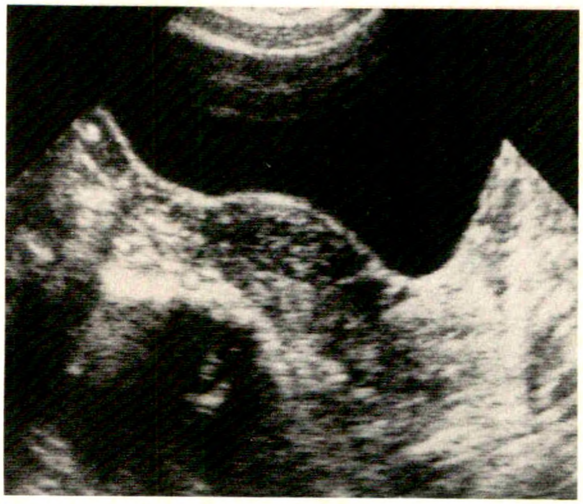

Figure 3. Longitudinal section of the uterus showing a mixed echopattern with transonic areas.

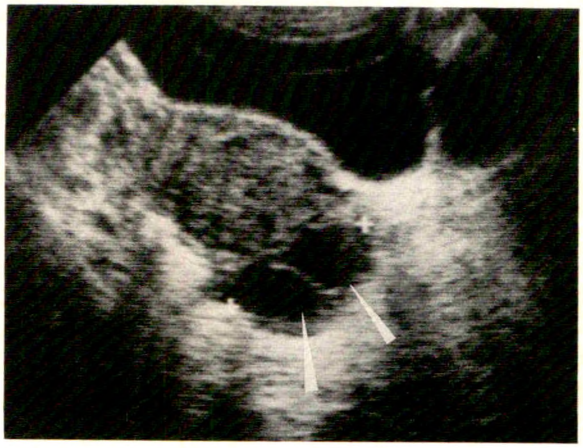

Figure 4. Transverse section of the uterus and left ovary demonstrating theca-lutein cysts (arrowheads).

Table II. Ultrasonic findings in seven patients with gestational trophoblastic disease who developed drug resistance ("abnormal uterus" refers to either volume or echopattern)

Normal uterus and ovaries	2
Abnormal uterus but normal ovaries	3
Normal uterus but ovarian cysts	1
Abnormal uterus and ovarian cysts	1
Total	7

bilateral cysts. Three cases showed cysts when the uterine volume was normal but the uterine appearances were abnormal. The remaining five cases with ovarian cysts had a raised uterine volume and were associated with an abnormal ultrasonic echopattern.

Drug resistance and relapse (Table II)

Seven patients in the study group developed drug resistance during their initial chemotherapy which was subsequently changed. At the end of treatment, two of these had a normal uterus and ovaries, one had a normal uterus but an ovarian cyst, three had an abnormal uterus but normal ovaries and one had abnormalities of both the uterus and ovaries.

Two patients relapsed after the end of chemotherapy. One had a normal uterine appearance but an ovarian cyst and the other had abnormal uterine and ovarian appearances and drug resistance had occurred during treatment.

There were no significant differences between those who relapsed and those who did not, with regard to abnormalities of uterine size or echopattern. Similarly, the presence of unilateral or bilateral ovarian cysts at the end of treatment did not affect outcome.

Discussion

The ultrasonic appearances of the uterus after chemotherapy for gestational trophoblastic tumours have not been previously described. The sonographic diagnosis of hydatidiform mole was first reported by MacVicar and Donald (1963) and the usefulness of ultrasound in differentiating between molar and viable pregnancies is now well established (Gottesfield et al, 1967; Leopold, 1971; Baird et al, 1977). Several studies have attempted to determine the ultrasonic appearances after molar pregnancy which may be used as a prognostic guide to the subsequent development of trophoblastic tumours requiring chemotherapy (Requard & Mettler, 1980; Santos-Ramos et al, 1980). However, the most sensitive marker for those who develop these tumours remains B-HCG estimation. We did not find any prognostic markers for recurrence of disease after chemotherapy from the ultrasound morphology of the uterus. The uterine appearances that we describe may be due to several features. Necrotic tumour and haemorrhage would result in increased and decreased echogenicity giving a mixed echopattern. Haemorrhage and blood clot may also account for cystic areas seen within the uterus. The uterine vessels can be markedly enlarged (Brewis & Bagshawe, 1968) resulting from dilatation of the local vasculature by trophoblast. These dilated vessels can be demonstrated ultrasonically and their presence confirmed using Doppler ultrasound (Long et al, 1987). These features would take time to resolve and the uterus would not be expected to have returned to normal at the end of chemotherapy.

A large uterine volume has been associated with a higher risk of developing primary drug resistance in the initial patient assessment prior to appropriate chemotherapy (Bagshawe, 1976). We did not find an increased incidence of relapse in patients whose uterine volume remained abnormal at the end of chemotherapy. However, in our series there were only two women who developed recurrent tumour. Follow-up of patients with an abnormal uterine volume after completion of chemotherapy has shown that the uterus slowly returns to normal in the absence of relapse as necrotic tumour resolves (Halpin, personal communication).

Woo et al (1985) described a grading system of the pre-treatment ultrasonic appearances of the uterus which correlated well with serum B-HCG levels and suggested that these appearances would be useful in monitoring response to chemotherapy or the presence of resistant disease. Our findings do not agree with this. We did not find any difference in the post-treatment features of the uterus of patients who relapsed and those who did not. Thus, ultrasound is not useful in detecting active residual tumour or those patients who will relapse. The monitoring of B-HCG levels remains essential in the detection of early relapse of these tumours.

The ovarian cysts detected are theca-lutein cysts which result from the luteinizing hormone effect of B-HCG on the ovary. Theca-lutein cysts have been documented to occur in approximately 40–50% of patients with molar pregnancies (Baird et al, 1977; Requard & Mettler 1980; Santos-Ramos et al, 1980). Prior to the widespread use of ultrasound it was thought that patients with theca-lutein cysts associated with hydatidiform mole were more at risk of developing invasive mole or choriocarcinoma (Curry et al, 1975; Morrow et al, 1977). However, this was not subsequently substantiated using ultrasound (Santos-Ramos et al, 1980). Our findings do not show that the presence of theca-lutein cysts at the completion of chemotherapy influences the relapse rate. These seem to be a consequence of prolonged high B-HCG levels and do not contribute to the trophoblastic disease process.

In conclusion, residual ultrasound abnormalities of the uterus and ovaries at the end of cytotoxic chemotherapy occur in approximately 70% of patients treated for gestational trophoblastic tumours. These features have not been found to indicate the presence of active residual tumour or increase the risk of recurrence. Although the change towards normality of the uterine ultrasound appearances correlates with therapeutic response, it does not provide an adequate end-point for treatment, and our conclusions differ from those of Woo et al (1985). Follow-up after treatment of these tumours should be with B-HCG quantification, and the duration of chemotherapy should not be based on ultrasonic findings.

Acknowledgment

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Magnetic resonance imaging of primary skeletal muscle diseases: patterns of distribution and severity of involvement

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Abstract. Magnetic resonance imaging of the lower extremities was performed with a low field system in 51 patients representing three different categories of biopsy-proven primary skeletal muscle disease: muscular dystrophies, congenital myopathies and polymyositis. The intermuscular distribution of abnormal signal intensity and the grade of involvement of individual muscles were assessed. Large differences in the degree of pathological signal intensity between individual muscles were found in all categories. In the muscular dystrophy and polymyositis patients, the overall involvement was significantly more severe than in patients with congenital myopathy. Definite patterns of selective involvement were seen. Statistical evidence of selective muscle sparing was found; the gracilis muscle was significantly less affected than the other muscles in all three disease groups. Other muscles with significant sparing include the rectus femoris and sartorius muscles of the thigh and the tibialis posterior muscle of the leg. Common anatomical and functional characteristics of muscles may be related to the distribution of muscular disease.

Musculoskeletal imaging has rapidly become the most important application of magnetic resonance (MR) imaging outside the central nervous system (Ehman et al, 1988). Evaluation of bone and soft-tissue tumours, joint disorders and diffuse and focal bone marrow disease have been the principal applications, but several studies have also shown the value of MR in disorders of skeletal muscle (Murphy et al, 1986; Schreiber et al, 1987; Lamminen et al, 1989). Developments in muscle disease research have demonstrated that involvement in muscular dystrophies can be highly selective (Gardner-Medwin, 1980), and imaging studies using computed tomography (CT) and ultrasound have also shown differences in findings between muscles and muscle groups (Hawley et al, 1984; Heckmatt et al, 1988). Because of its good soft-tissue contrast resolution, MR imaging seems to be a promising tool for the evaluation of differences in muscle disease distribution and severity. The studies on MR of muscular disease published so far have described findings in relatively few patients with biopsy-proven disease, and comparative analyses of pathological findings between different disease categories have been scarce.

The present study is an assessment of MR findings and selectivity of involvement in three patient groups with skeletal muscle disease: (I) muscular dystrophies, (II) congenital myopathies and (III) polymyositis and dermatomyositis.

Patients and methods

A total of 51 patients were examined and divided into three separate groups. A description of the patient groups and detailed diagnoses is shown in Table I. Group I (muscular dystrophies) consisted of 21 male and 11 female patients (ages 4.1–49.4 years; mean, 20.2 years). Group II (congenital myopathies) contained six male and five female patients (ages 3.0–76.2 years; mean, 30.6 years). In Group III (polymyositis and dermatomyositis) there were four male and four female patients (ages 7.1–80.3 years; mean, 45.8 years). In all patients, the diagnosis was based on the results of a muscle biopsy. Average duration of symptoms was 8.0 years in Group I, 5.0 years in Group II and 5.4 years in Group III.

A resistive whole body magnetic resonance imaging system operating at 0.02 T, corresponding to a proton resonance frequency of 0.833 MHz (Instrumentarium Corp., Helsinki, Finland) was used. Transaxial slices of both thighs and legs were obtained with a close-coupled receiver coil; slice thickness was 10 mm. Matrix size was 128 × 256. In all patients, a partial saturation (PS) sequence with a repetition time (TR) of 1000 ms and an

Table I. Muscle disease patients studied by magnetic resonance imaging

I. Muscular dystrophies:	$n = 32$
Duchenne dystrophy	6
Becker-type dystrophy	1
Limb-girdle dystrophy	10
Muscle–eye–brain disease	9
Unclassified dystrophy	6
II. Congenitial myopathies:	$n = 11$
Multicore myopathy	2
Fibre-type disproportion disease	3
Unclassified myopathy	6
III. Polymyositis and dermatomyositis:	$n = 8$
Polymyositis	7
Dermatomyositis	1
Total	51

echo delay time (TE) of 60 ms was used. In 32 patients, a PS 250/40 ms (TR/TE) sequence was also employed. The term partial saturation sequence is used according to the definition of Bydder and Young (1985); an excitation technique using repeated 90° radiofrequency pulses with data collection by gradient field reversal.

In each patient, individual muscles were evaluated with a quantitative four-point grading scale; the intensity of subcutaneous fat was used as a reference (Dooms et al, 1986). For purposes of anatomical clarity and synergistic function, some muscles were graded together as a muscle group. Grade definitions are as follows:

Grade 1: normal muscle signal intensity (homogeneous, hypointense signal, contrasting sharply with subcutaneous and intermuscular fat; as reported in Murphy et al, 1986).
Grade 2: slightly hyperintense, patchy intramuscular signal changes.
Grade 3: markedly hyperintense, patchy but widespread intramuscular signal changes.
Grade 4: total, homogeneous hyperintense signal change in whole muscle, equalling the signal intensity of adjacent subcutaneous or paramuscular fat.

Non-parametric Wilcoxon and Mann–Whitney ranking tests were used for statistical analysis.

Results

Differences in the degree of abnormal signal intensity were seen between the individual muscles and muscle groups with both PS 1000/60 ms and PS 250/40 ms sequences. Subcutaneous fat was seen as the tissue of highest signal intensity with both sequences. Abnormal signal intensity in muscles was variable: in some muscles, only a very slight, patchy intramuscular increase in signal was seen, whereas in other muscles, homogeneous hyperintense change in signal equalled the signal intensity of adjacent fat (Fig. 1).

Differences in disease distribution and severity between individual muscles were seen both at the proximal (thigh) and distal (leg) level in all patients. Asymmetry of muscular involvement between right and left sides was seen. The mean grade values of the muscles and muscle groups are shown in Table II.

Definite patterns of muscular involvement can be recognized. In the dystrophy group, the vastus lateralis, vastus intermedius, biceps femoris, semimembranosus and gastrocnemius muscles were more severely involved than the other muscles, whereas the rectus femoris, sartorius, gracilis and tibialis posterior muscles were less

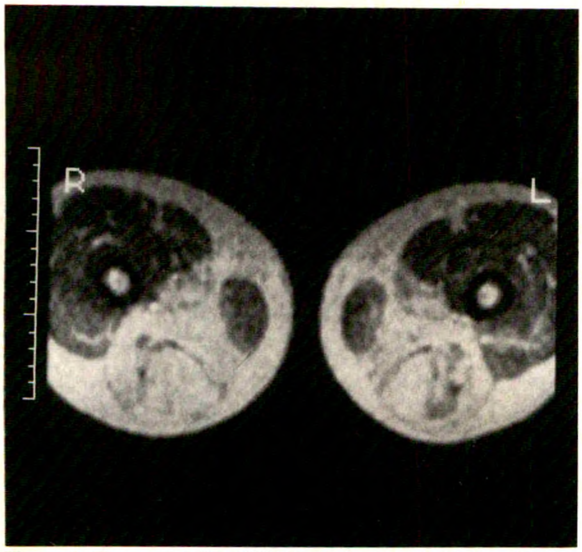

Figure 1. Transaxial PS 1000/60 ms image of thighs of a 31-year-old man with limb-girdle muscular dystrophy. Selective bilateral involvement of the hamstring and adductor groups of muscles. The abnormal signal intensity of muscles equals the signal of adjacent fat.

Table II. Mean muscle MR grade values in patients with skeletal muscle disease

	Dystrophies ($n = 32$) Right/Left	Myopathies ($n = 11$) Right/Left	Polymyositis ($n = 8$) Right/Left
Thigh			
Rectus femoris muscle	1.9/1.8	1.1/1.0	1.9/2.0
Vastus lateralis muscle	2.6/2.4	1.4/1.1	2.5/2.6
Vastus intermedius muscle	2.4/2.3	1.3/1.2	2.5/2.6
Vastus medialis muscle	2.4/2.2	1.3/1.2	2.5/2.6
Sartorius muscle	1.9/1.7	1.0/1.0	2.0/2.0
Adductor magnus, longus and brevis muscles	2.3/2.4	1.2/1.1	2.1/2.2
Gracilis muscle	1.4/1.4	1.0/1.0	1.4/1.4
Biceps femoris muscle	2.7/2.7	1.5/1.2	2.1/2.0
Semitendinosus muscle	2.1/2.1	1.2/1.2	1.8/1.6
Semimembranosus muscle	2.5/2.6	1.3/1.3	2.0/1.9
Leg			
Tibialis anterior and extensor digitorum longus muscles	2.0/1.9	1.7/1.6	1.9/1.9
Peroneus longus and brevis muscles	2.1/2.0	1.3/1.0	2.0/2.1
Tibialis posterior muscle	1.4/1.3	1.2/1.1	1.1/1.1
Soleus muscle	2.5/2.3	1.4/1.3	1.5/1.5
Gastrocnemius muscle	2.8/2.6	1.4/1.2	2.4/2.4

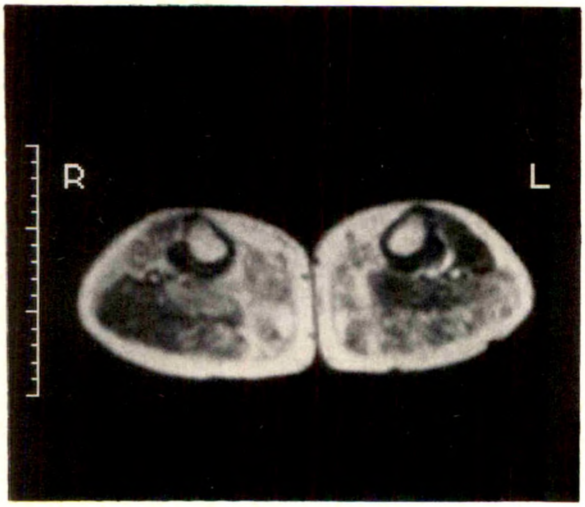

Figure 2. Transaxial PS 1000/60 ms image of legs of a 9-year-old boy with Duchenne dystrophy. Variable bilateral involvement of the gastrocnemius and soleus muscles with unilateral right-sided involvement of the tibialis anterior and extensor digitorum longus muscles. Note bilateral sparing of the tibialis posterior muscles.

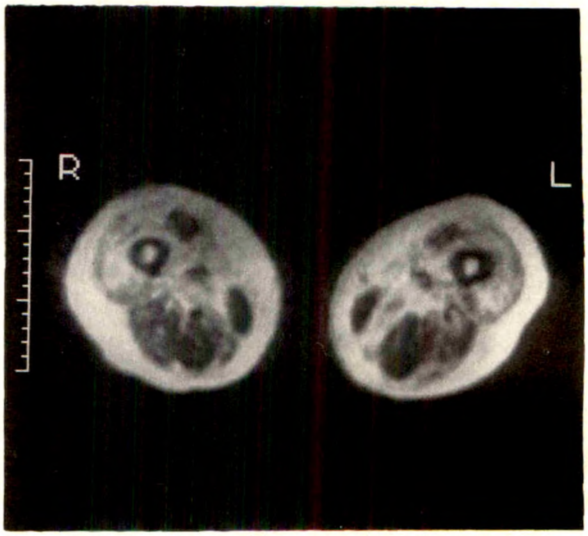

Figure 4. In this 61-year-old-woman with polymyositis, selective muscular involvement is seen especially in the vastus and adductor muscles, whereas the rectus femoris, gracilis and semitendinosus muscles are less affected. A transaxial PS 1000/60 ms image of thighs.

affected (Figs 2 and 3). These differences were statistically significant ($p<0.01$).

The severity of muscular involvement in the polymyositis and dermatomyositis group of patients was rather similar to that of the dystrophy patients, with the exception of less severe findings in the soleus muscle. Statistically significant ($p<0.05$) evidence of selective sparing was found in the gracilis, tibialis posterior and soleus muscles (Fig. 4).

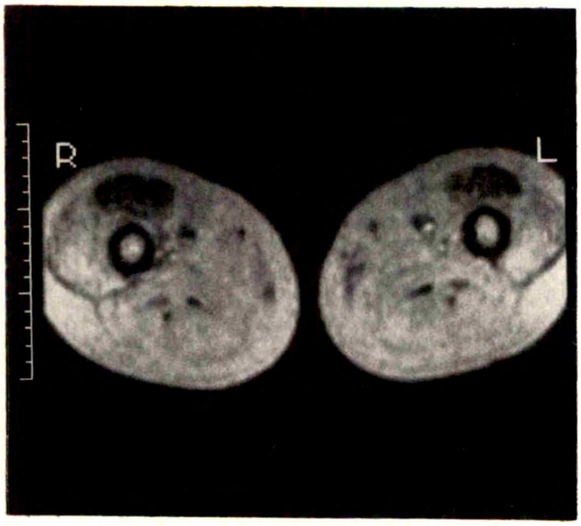

Figure 3. Selective muscular sparing: in a transaxial PS 1000/60 ms image of thighs of a 35-year-old woman with limb-girdle muscular dystrophy, all muscles are seen to be severely abnormal, with the exception of both rectus femoris muscles, which are relatively spared.

In the congenitial myopathy group, overall involvement of the musculature was significantly less severe than in patients with dystrophies or polymyositis; the muscles of the anterior compartment of the leg (tibialis anterior and extensor digitorum longus) were more involved than the other muscles, although this difference was statistically not significant. In this group, the significantly ($p<0.05$) less involved muscles were the rectus femoris, sartorius and gracilis. Table III summarizes the patterns of selective muscular sparing in the three disease groups.

Discussion

In recent years, application of imaging methods to the evaluation of primary skeletal muscle diseases has increased; earlier attempts to characterize muscular

Table III. Patterns of significantly spared muscles ($p < 0.05$) in three groups of muscle disease patients

	Dystrophies ($n = 32$)	Myopathies ($n = 11$)	Polymyositis ($n = 8$)
Thigh	Gracilis	Gracilis	Gracilis
	Rectus femoris	Rectus femoris	
	Sartorius	Sartorius	
Leg	Tibialis posterior		Tibialis posterior
	Tibialis anterior		Soleus
	Extensor digitorum longus		

disorders include plain film radiography (DiChiro & Nelson, 1965) and radionuclide studies (Brown et al, 1981), but these methods are quite imprecise, particularly with regard to disease distribution and severity. New modalities, primarily ultrasound (Heckmatt et al, 1988) and CT (Hawley et al, 1984) have proved to be more effective for surveying skeletal muscle diseases. However, the interpretation of real-time ultrasound studies is operator-dependent, and identification of individual muscles can be a problem. Computed tomography allows objective assessment of muscle size, contour and X-ray attenuation values, but, in the extremities, CT images may be degraded by beam hardening artefacts from cortical bone. Also, the use of ionizing radiation in children and young adults should be limited to a minimum.

Magnetic resonance imaging offers potentially better soft-tissue contrast resolution than CT, and, in routine clinical use, the modality has no known biological hazards; this is especially true for lower magnetic fields (Budinger, 1981), and of importance if sequential imaging studies are needed to follow disease progression.

In spite of a relatively low signal-to-noise ratio, low field MR imaging offers potentially good contrast resolution (Agartz et al, 1987), with some differences from experience at high fields. At 0.02 T, the T_1 relaxation time values of normal muscle and fat are quite close to each other, whereas there is a considerable T_2 difference. The PS 1000/60 ms sequence was used in most patients because of better contrast sensitivity between fat and muscle owing to the T_2 weighting.

The abnormal, increased intramuscular MR signal intensity seen in this study was interpreted for the most part to represent fatty degeneration of muscle; in advanced cases, the abnormal signal equalled that of subcutaneous fat. This was seen with both pulse sequences that were employed. The fatty nature of similar intramuscular signal changes at 0.02 T has been confirmed by chemical shift imaging (Lamminen et al, 1990). However, because of the relative T_2 weighting of the PS 1000/60 ms images, increased free water fraction of diseased muscle tissue may also play a role; in experimental animal studies, Chang et al (1981) found that the water content of dystrophic muscles was increased. In humans with Duchenne dystrophy, the bound water fraction was found to be decreased (Matsumura et al, 1988); this evidence supports the hypothesis of increased intramuscular free water in diseased muscle.

Despite the proliferation of clinical and laboratory research on the muscular dystrophies and other primary muscle diseases, many unsolved problems remain. An interesting question is why diseases that seem to be the result of a specific genetic defect common to all muscle cell nuclei (Hoffman et al, 1987) can be so selective in the way in which they affect individual skeletal muscles throughout the body. In the present study, definite patterns of selective involvement were seen in all three disease groups. Some muscles were selectively spared, especially the gracilis, rectus femoris and sartorius muscles of the thigh and the tibialis posterior muscle of the leg. Selective sparing of muscles was also seen in all patients with polymyositis and dermatomyositis, contrary to a previous report, where only one of 13 patients had focal abnormalities (Kaufman et al, 1987).

Skeletal muscle fibres can be classified into two basic types on the basis of their metabolic and electrophysiological characteristics; slow-twitch (Type I) and fast-twitch (Type II) fibres. The relative distribution of the two types varies from muscle to muscle, and this can be demonstrated by histochemical methods (Johnson et al, 1973). When considering the findings of the present study, no simple correlation emerges between the fibre type composition of muscles and their involvement; both predominantly Type I (soleus, tibialis anterior) and Type II (rectus femoris) muscles were selectively spared.

In the thigh, common anatomical characteristics can be found among the selectively spared rectus femoris, sartorius and gracilis muscles. All these are stretched out, fusiform muscles that extend over two joints of the lower extremity, with their origins in the pelvis and insertions in the tibia; also the rectus femoris is regarded as having a tibial insertion via the quadriceps and patellar tendons. They can be regarded as extensible ligaments coupling the hip and knee joints (McLeod, 1971). Anatomical, and thus functional, factors may be connected with the distribution of muscular disease (Edwards, 1980).

The following conclusions can be drawn from this study. (1) Magnetic resonance imaging of patients with muscle disease discloses large differences in the degree of abnormal signal intensity between individual muscles. (2) Different patterns of abnormal muscle involvement can be seen between major categories of muscle disease. (3) In all disease categories, certain muscles are significantly less affected than others; common anatomical and functional characteristics may be responsible for this phenomenon.

Magnetic resonance imaging seems very suitable for muscle imaging in clinical practice. Accurate identification of the involved muscles is useful in guiding a diagnostic muscle biopsy, and pitfalls in the physical examination can be avoided; sometimes muscle size and contour may remain unchanged, even when extensive intramuscular pathological MR signal change has taken place.

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The influence of a seventy-two hour gap on the acute response of mouse skin and oesophagus

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Abstract. The sparing effect of a 72 h gap, inserted after the third, sixth or ninth fraction of a 12 fraction X-ray schedule, was investigated in two early responding normal tissues: mouse skin and oesophagus. Acute skin reactions and body weight loss were used as assays to quantify changes in the radiation tolerance of these tissues. In skin, no evidence of compensatory proliferation was seen if a gap was inserted, whatever its position in the schedule. In oesophagus, a small but significant increase in radioresistance was observed if the gap was positioned ¼ of the way through treatment compared with the schedule delivered without an interruption (12F/12 days). Although an increase in normal tissue tolerance is not observed by increasing the overall time from 12 to 15 days, provided tumour clonogen proliferation does not occur during the weekend split, the insertion of a gap makes continuous accelerated clinical regimes, currently given without an interruption at weekends, easier to introduce into wider clinical practice.

Repopulation in most early responding tissues begins shortly after the start of treatment (Withers, 1985), so with protracted overall times, as in conventional radiotherapy, a larger total dose can be given without causing severe acute reactions, and treatment tolerance is dictated by the degree of late morbidity which is deemed acceptable. However, there is strong clinical and experimental evidence that protraction of treatment reduces the radiocurablity of some tumours because of this same proliferation protection (Parsons et al, 1980; Overgaard et al, 1988). Fast proliferating tumours should therefore benefit from regimes that shorten the overall treatment time (*i.e.* accelerated fractionation), since the extent of tumour clonogen repopulation that occurs with prolonged overall time is decreased (Thames et al, 1983; Peters et al, 1988). However, these schedules also reduce the amount of compensatory proliferation in early responding tissues, which then may become dose limiting, and increase the late radiation morbidity that could ensue from severe and persistent acute reaction.

An experimental clinical regime is being used where both the dose per fraction (to spare late radiation damage further) and the overall treatment time are reduced (Saunders et al, 1989). With continuous hyperfractionated accelerated radiation therapy (CHART), 36 fractions, to a total dose of 54 Gy (1.5 Gy per fraction), are delivered in 12 days as 3 fractions/day with daily interfraction intervals of 6 h, to tumours of the head and neck region and carcinoma of the bronchus. Currently, treatments are not interrupted during the weekend; this precludes implementing such schedules, however successful the outcome, in most other

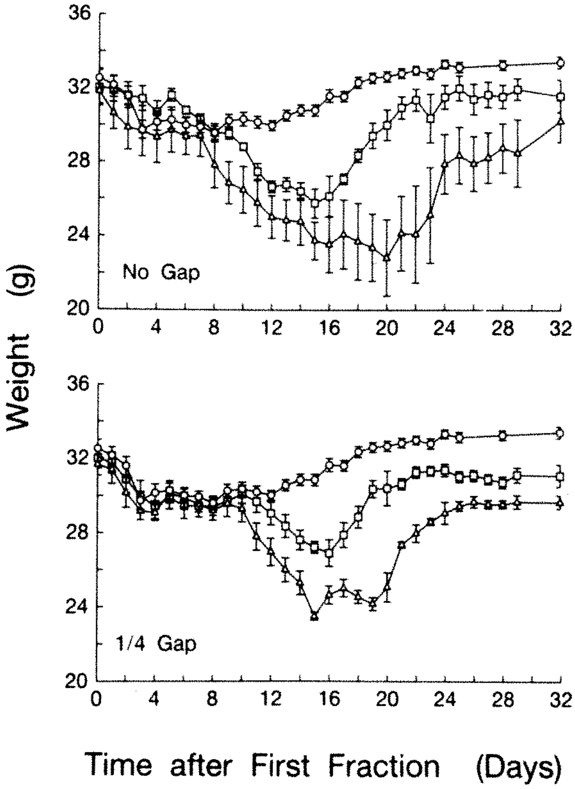

Figure 1. Mean weight for CBA male mice (±1 sem) during and after a course of fractionated X rays, for a total dose of 70 Gy (□) or 80 Gy (△), given either as 12F/12 days (top) or as 12F/15 days and inserting a gap after the third fraction (bottom). Sham-irradiated controls (○) are also shown. The nadir of weight loss occurred at a similar time after treatment for both radiation schedules.

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centres, mainly because of the added financial and social burdens. Furthermore, to avoid working over too many weekends during the year, treatments for a new group of patients must be planned to start on one or at most two mondays in a particular month, which complicates the logistics of patient accrual.

Although results obtained so far with CHART are promising, it is desirable to determine whether introducing a weekend gap would increase acute normal tissue tolerance, thus allowing an increase in total dose, and would also avoid the need to treat patients during weekends. We therefore investigated the sparing effect of a 72 h interval, during the course of a fractionated regime, on mouse skin and oesophagus and whether such a gap positioned early on, midway or towards the end of treatment would be more or less effective at sparing acute normal tissue damage. Oesophagus and skin were chosen as examples of early reacting normal tissues because the former is inevitably included in the treatment beam of most thoracic tumours and the latter may have a time scale for expression of and healing from radiation damage similar to human oral-pharyngeal mucosa (Withers, 1989; Tsang et al, 1990), which along with the oesophagus is a dose-limiting site with CHART.

Materials and methods

Skin

Adult albino female mice WHT/GyfBSVS, 10–11 weeks old, were used for this experiment. After irradiation, acute skin reactions were measured using an arbitrary scale for erythema, oedema and dry and moist desquamation (Denekamp, 1973; Douglas & Fowler, 1976). Reactions were scored three times a week from 7 to 40 days after the first X-ray treatment. An average score was calculated for each mouse over a period of 14–36 days after the first X-ray treatment, or an equivalent period if the reaction appeared slightly earlier or later (Denekamp, 1973; Tsang et al, 1990). The mean reaction ±1 sem was then calculated for each group. Although a period of 10–32 days is usually used for averaging skin reactions at the Gray Laboratory (Denekamp, 1973; Joiner et al, 1986), because the

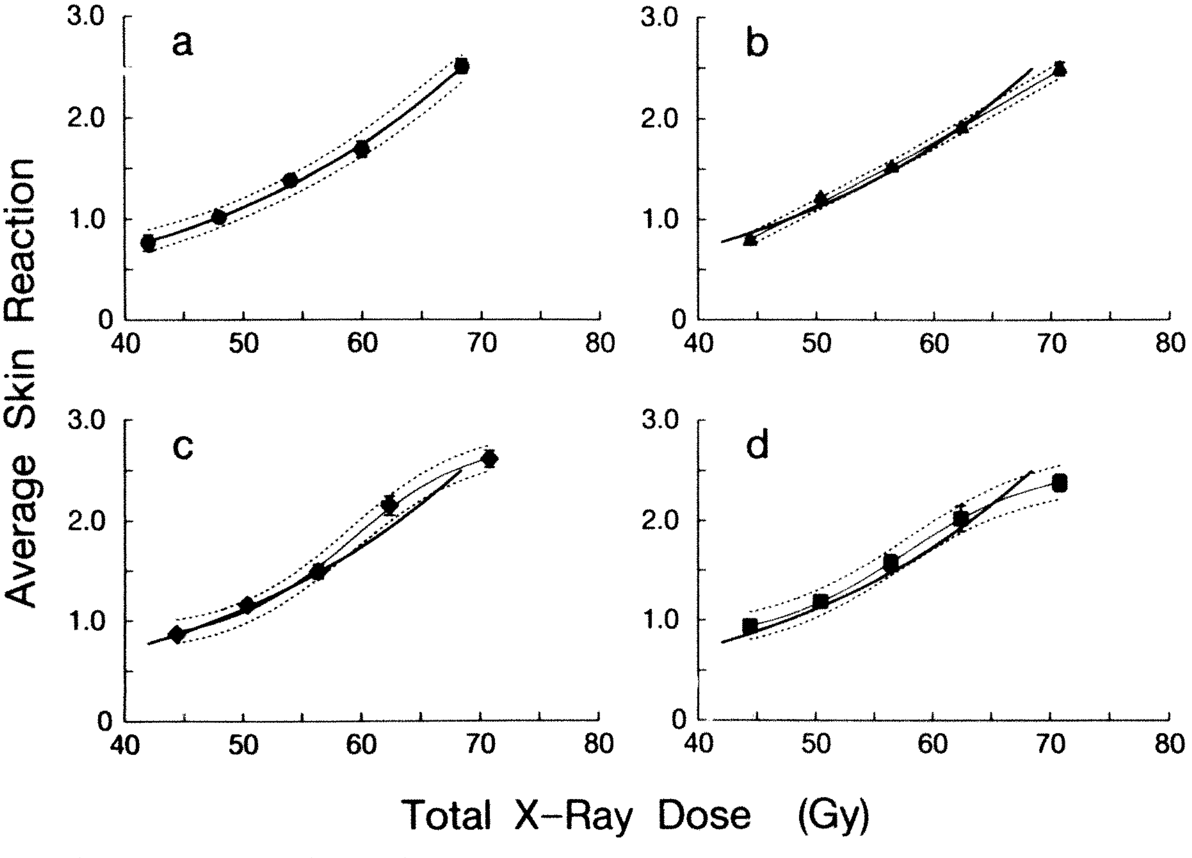

Figure 2. Dose–response curves for acute skin reactions (±1 sem) for 12 fractions given (a) in 12 days or in 15 days, with a gap inserted (b) ¼, (c) ½ or (d) ¾ of the way through treatment. For comparison, the 12F/12 day dose–effect curve is reproduced as the thicker solid line in all other panels. No increase in skin tolerance was observed for any of the extended overall treatment times. The dotted lines are the 95% CL.

overall treatment time in this present study was 12 or 15 days, a slightly later starting day (*i.e.* Day 14) was used.

Oesophagus

Adult CBA/GyfBSVS male mice, 12–13 weeks old, with a weight range of 32±1 g (SD) were used. Decreased food intake, body weight loss and lethality after whole thorax irradiation in rodents have all been shown to be caused primarily by acute and subacute oesophageal damage and to be good indicators of oesophageal response (Kurohara & Casarett, 1972; Phillips & Margolis, 1972; Phillips & Ross, 1974). It was shown that lethality due to epithelial denudation occurred over a well defined period of time, with dehydration and starvation as the main cause of death, and no evidence of mediastinitis and/or oesophageal perforation was seen (Phillips & Ross, 1974). By contrast, Michalowski and Burgin (1982) have suggested that duodenal ulcers, induced as an abscopal effect of thoracic irradiation, and not acute oesophagitis would be the mechanism of death. In our studies, although body weight loss and not lethality was chosen as the end-point, some animals died or were sacrificed because of unacceptable general conditions. These deaths occurred over a period of time similar to that reported by Kurohara and Casarett (1972) and Phillips and Ross (1974) and we saw no evidence of gastric or duodenal ulcers in these animals. Using weight loss as an end-point, we previously obtained well defined dose–response relationships for different fractionation schedules and radiomodifiers (Hirn-Stadler et al, in preparation).

Assays

The animals were weighed just before the first X-ray fraction and subsequently on successive days thereafter for a total of 35 days. Four animals were used per dose group.

Weight at nadir. The weight at nadir was the lowest weight attained by an animal after the completion of a fractionation regime. On average, the nadir of weight loss was observed 5–7 days after completion of treatment. The mean nadir weight (±1 sem), was calculated for each dose group and plotted against X-ray dose.

Average weight loss. Weights of individual animals, expressed as a proportion of sham-irradiated control mice, were calculated for a period of 12 days after the end of a regime. An average relative weight was obtained for each mouse over this period (14–26 days

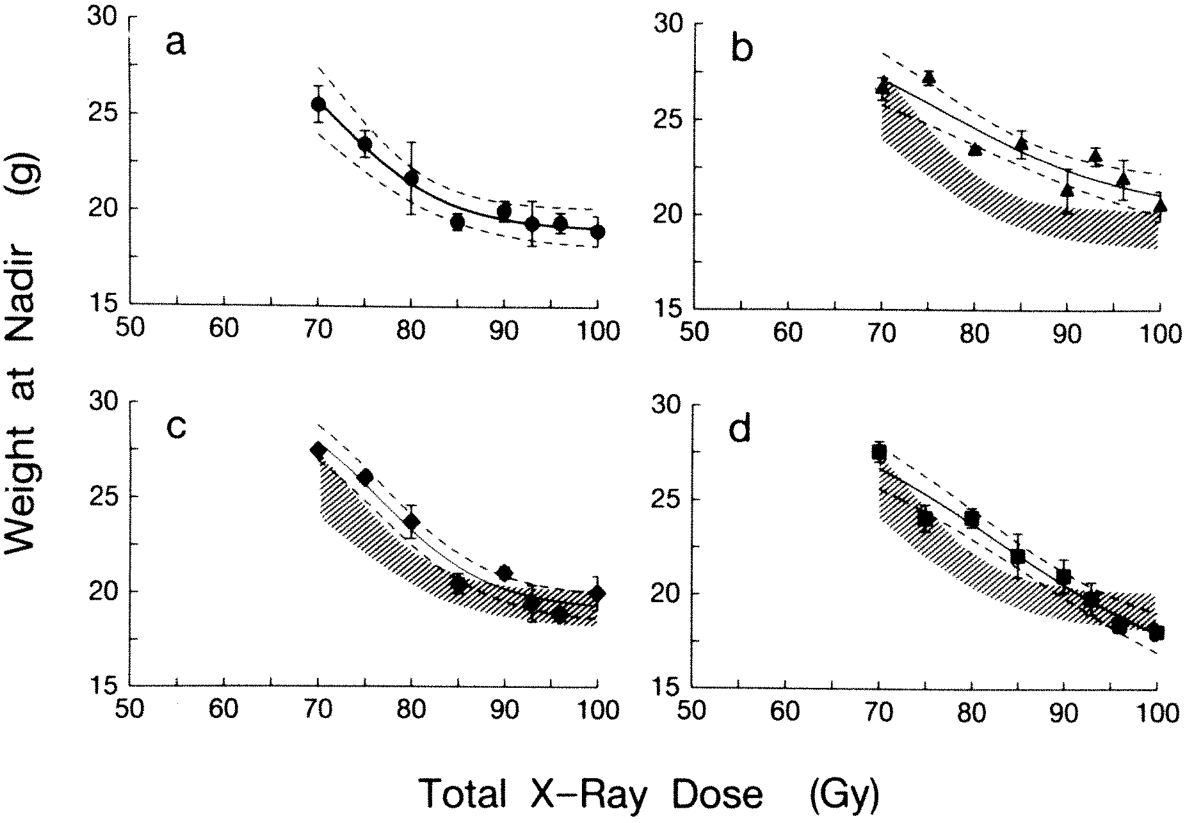

Figure 3. Dose–response curves for mean weight at nadir (±1 sem) for 12F/12 days (●) or for 12F/15 days with a gap after the third, sixth or ninth fraction (▲, ◆, ■, respectively). The dashed lines are the 95% CL. A slight increase in radioresistance was seen when the gap was positioned shortly after the start of treatment (b). The shaded area here represents the response to 12F/12 days with the 95% CL.

for 12F/12 days and 16–28 days for the 12F/15 day schedules). The mean weight loss ±1 sem was then calculated for each group. This averaging period of 12 days was considered adequate and, as shown in Fig. 1, covers the period preceding the nadir, then the nadir and the recovery phase. Some animals in the top dose groups died or were sacrificed because of their much deteriorated general conditions. These mice were included in the analysis and given a nominal weight loss of 19.7 g, which represents the mean weight of all the animals that died or were killed during the course of the experiment. The average time of death was 19 days after the first X-ray treatment.

ED_{50} analysis. The mean nadir weight of all animals in the experiment, including "dead responders" but not sham-irradiated controls, was 23 g. The number of mice whose weight was $\leqslant 23$ g, after completing the fractionated schedule, was determined for each dose group and the resulting quantized data fitted by logit analysis.

Irradiations

X rays were generated with a Pantak set operating at 240 kVp and 15 mA, filtered with 0.25 mm Cu and 1.0 mm Al (HVL = 1.3 mm Cu). The dose rate was 1.8 Gy/min and 2.3 Gy/min for the oesophageal set-up and the skin irradiation set-up, respectively. For the oesophagus, an anterior-posterior field 7 mm wide by 17 mm long, which included the mediastinum and only the central parts of the lungs, was defined with the use of diagnostic X rays. Four unanaesthetized mice, under air-breathing conditions, were irradiated at a time; the dose uniformity at the four positions was within ±0.2%. In the skin experiment, mice were locally irradiated without anaesthetics with the animals breathing oxygen to avoid possible varying degrees of hypoxia in the feet, thus achieving uniform sensitivity at each treatment. The animals were restrained in lead boxes from which the left hind leg protruded and was held gently in the irradiation field by means of three Perspex posts. This arrangement is similar to the one described by Douglas and Fowler (1976) and modified by Joiner et al (1986) and has a dose variation between the four feet of <0.3%.

Experimental design

The same experimental design was used for both skin and oesophagus. Twelve fractions were given either in an overall time of 12 days (*i.e.* no gap) or of 15 days; the

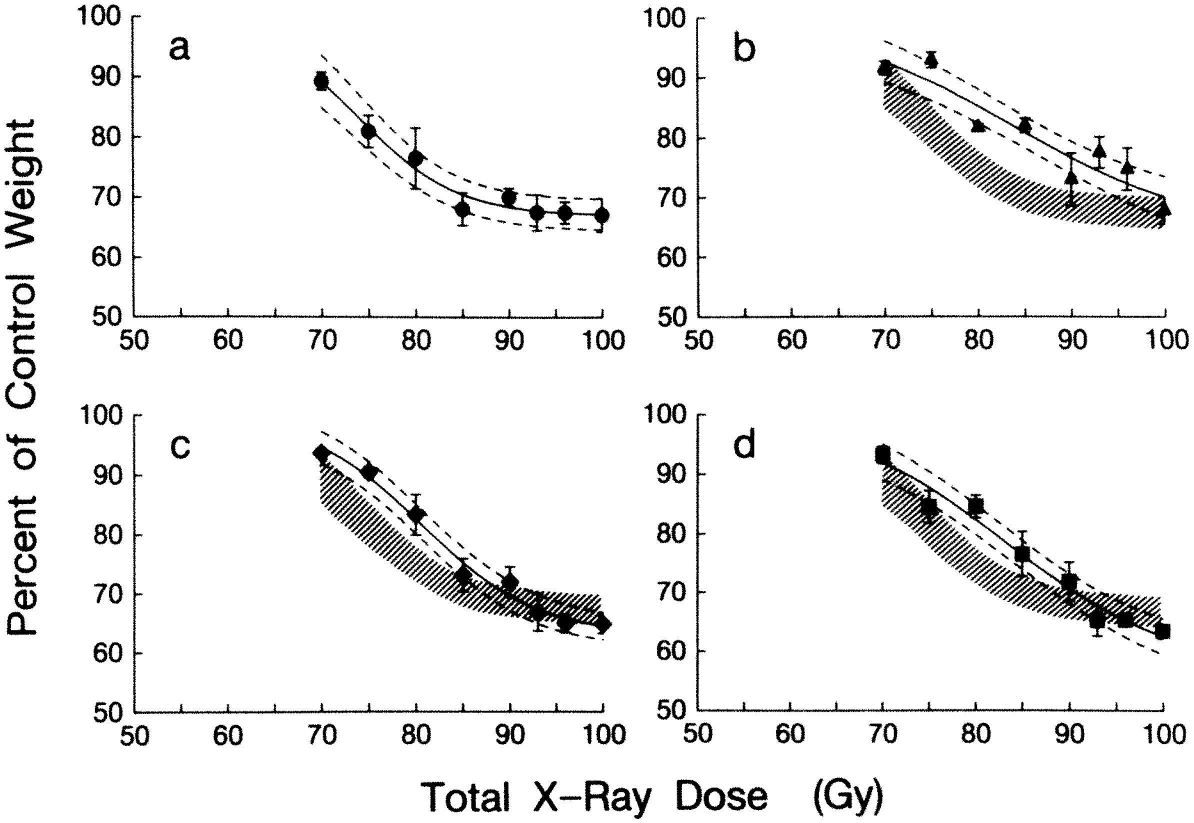

Figure 4. Average weight loss, expressed as a percentage of sham-irradiated controls, over a period of 14–26 days for 12F/12 days (panel a), or 16–28 days for 12F/15 days with a gap inserted $\frac{1}{4}$, $\frac{1}{2}$ or $\frac{3}{4}$ of the way through treatment (b to d, respectively). The dashed lines are the 95% CL. The shaded area represents the response to 12F/12 days with the 95% CL. As with the other methods of analysis, some sparing of damage was seen with the gap positioned shortly after the start of treatment (▲).

72 h gap was introduced after the third, sixth or ninth fraction. For skin, a dose per fraction range of 3.5–5.9 Gy was used and 5.8–8.3 Gy for the oesophagus.

Dose–response curves

The response of skin and oesophagus was plotted against dose as the mean and standard error for the mice in each dose group (four animals per group). The dose–response curves for average weight loss, weight at nadir and skin reactions were determined objectively by least-squares non-linear regression, using a generalized logistic function fitted to all the individual measurements for each mouse. Objective values of isoeffect doses were obtained for each curve by back-substitution in the equation fitted to each set of data points by the regression analysis (Joiner et al, 1989).

Results

Figure 2 shows dose–response curves for acute skin reactions for 12 fractions given in 12 days (panel a) or in 15 days. With the longer overall treatment time, a 72 h gap was introduced $\frac{1}{4}$ (panel b), $\frac{1}{2}$ (panel c) and $\frac{3}{4}$ (panel d) of the way through treatment. The dotted lines represent the 95% CL obtained with the regression fit. For ease of comparison, the dose–response curve for 12F/12 days was reproduced in panels b to d as the thicker solid line. In this study, increasing the overall time from 12–15 days did not decrease the radiosensitivity of mouse skin; there was no indication of compensatory proliferation during the 72 h gap, whatever its position in the schedule.

Figures 3 and 4 illustrate the response of mice to localized mediastinal irradiation. The weight at nadir and the average weight loss over a period of 12 days are shown for 12F/12 days (panel a) and 12F/15 days (panels b to d in both diagrams). The shaded area in these panels represents the response curve (±95% CL) for 12F/12 days. Although the difference was not statistically significant, there was an indication of a slightly more resistant response with the longer overall times for both methods of analysis, especially when a gap was introduced $\frac{1}{4}$ of the way through treatment (panel b).

The proportion of mice whose weight was $\leqslant 23$ g is shown as a function of the total X-ray dose in Fig. 5. The response to 12F/12 days (panel a) is reproduced in all other panels as the dashed line. The errors at the ED$_{50}$ level (*i.e.* the dose required to reduce the body

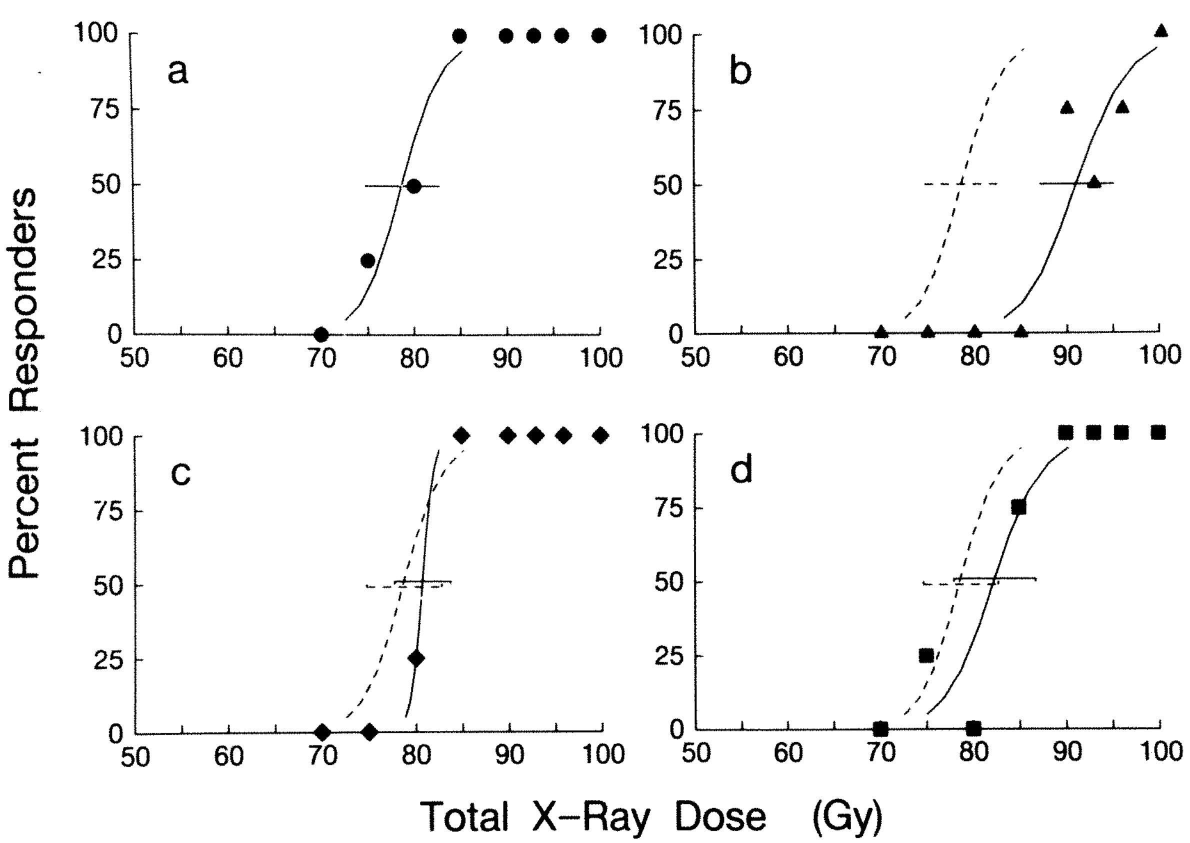

Figure 5. Percentage of mice whose weight after the end of treatment was $\leqslant 23$ g for the four fractionated regimes. For comparison, the 12F/12 day schedule (a) is reproduced as a dashed line in b to d. Dose–effect curves for the interval positioned after the first three fractions (▲) show a significant increase in radioresistance. Errors are 95% CL.

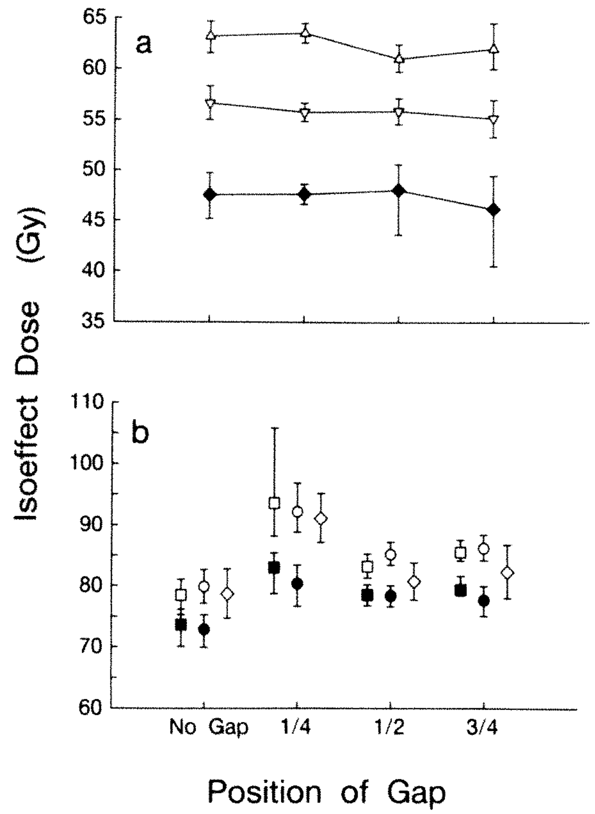

Figure 6. (a) Isoeffect doses (±95% CL) calculated for a skin reaction level of 1.0 (◆), 1.5 (▽) and 2.0 (△) for the four different fractionated regimes. There was no increase in the total dose required to achieve a particular level of damage when the overall time was increased from 12 to 15 days. (b) Isoeffect doses (±95% CL) required to reduce the weight to 15% (●) or 25% (○) of sham-irradiated controls, to achieve a nadir weight of 24 g or 22 g (■, □, respectively), or reduce the body weight in 50% of the mice to 23 g or less (◇). A small but significant increase in oesophageal tolerance was observed when the gap was introduced ¼ of the way through treatment, especially at the higher levels of effect.

weight to 23 g or less in 50% of the animals) are 95% CL. The dose–response curves for the extended overall time were all to the right of the 12F/12 day regime; however, a significant increase in radioresistance was only observed, as for the two previous methods of analysis, with the gap positioned ¼ of the way through treatment.

Total isoeffect doses (±95% CL) for three different levels of skin reaction (panel a) and for the three different methods for analysing weight loss (panel b) are shown in Fig. 6. In skin, there was no difference in the total dose required to obtain any particular level of reaction (panel a). In oesophagus, a slight but significant increase in total dose was observed, at the higher effect levels, when the gap was placed ¼ of the way through treatment.

Discussion

In skin no evidence was seen of increased tolerance to radiation damage when inserting the equivalent of a weekend gap during a course of fractionated radiotherapy and extending the overall time from 12 to 15 days. Although some studies suggest that compensatory proliferation in rodent skin starts at ~10 days (Denekamp, 1973; Ang et al, 1984) after the first fraction, others have reported a significantly longer time factor (Moulder & Fischer, 1976; Tsang et al, 1990). Since a variety of time–dose-fractionation schedules have been used in repopulation studies, a single time factor for different X-ray regimes is probably inappropriate. Furthermore, Ang et al (1985) showed that the manner in which the fractions were distributed (*i.e.* the daily dose rate), in regimes using the same number of fractions and overall time, greatly influenced the amount of compensatory proliferation in lip mucosa. Recently, we have observed that the rate of accelerated repopulation depends on the degree of initial damage, with the fastest rate of repopulation obtained in treatments continued into the time when skin reactions were seen, suggesting that for rapid healing to ensue, the gap should only be placed after the tissue has started to express functional damage (Tsang et al, 1990). Using a 36 fraction 12 day schedule (1.2–2.3 Gy per fraction, and therefore well within the clinical dose range), given as 3 fractions/day at 6 h intervals, the latent period, the rate of appearance and the peak levels and time to healing of skin reactions were no different from when a 12 fraction 12 day regime was used (Rojas & Ninis, 1987). Therefore in clinical accelerated regimes given in very short overall times, and which only elicit subthreshold damage before their termination, it seems unlikely that an increase in tissue tolerance will be seen if a weekend split is introduced.

In oesophagus only minimal sparing using split-dose treatments with overall times as long as 25 days has been reported (Phillips & Ross, 1974). In our animals, we observed a small but significant increase in tolerance when the gap was positioned ¼ of the way through treatment. However, it is improbable that this increased radioresistance is due to compensatory repopulation. Probably, insertion of an early gap prevents the cells distributing themselves into more sensitive phases of the cell cycle and hence a slightly more resistant response was obtained. Regeneration in the oesophagus commences 7–14 days after a single dose of X rays (Kurohara & Casarett, 1972; Phillips & Ross, 1974). A dose >20 Gy to the whole thorax produced a loss of proliferating cells in the basal layer of the epithelium, which led, 3–5 days after, to progressive and marked reduction of the differentiated squamous cells and of the keratin layer. Denudation and thinning of the epithelium was followed, 1–2 weeks later, by foci of proliferating basal cells and inflammatory infiltrate in the submucosa (Phillips & Ross, 1974). Areas of denudation were seen to coexist with areas of regeneration and these structural changes coincided well with changes in body weight and lethality (Kurohara & Casarett, 1972;

Phillips & Margolis, 1972; Phillips & Ross, 1974). Proliferation studies on mouse skin indicate that repopulation of mouse oesophageal epithelium, after fractionated treatments, would start later rather than earlier than the time scale seen with large single doses (Denekamp, 1973; Tsang et al, 1990).

In conclusion, using a once a day fractionation regime and extending the overall time from 12 to 15 days did not increase the acute radiation tolerance of skin or the oesophagus. Since a 36 fraction 12 day treatment in mouse skin (*i.e.* a CHART type schedule) did not produce reactions any more severe than a 12F/12 day regime (Rojas & Ninis, 1987), it seems unlikely that it could stimulate cells into an accelerated rate of repopulation more effectively than a 12F/12 day schedule (Tsang et al, 1990). Thus, in continuous accelerated regimes given in very short overall times, inserting the equivalent of a weekend gap does not seem to warrant an increase in total dose; however, provided tumour clonogens do not proliferate during the 72 h split, the introduction of a weekend gap would be beneficial to the implementation of CHART-like regimes in most radiotherapy centres.

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Direct analysis of quantitative data from radiobiological studies on pig lung

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Abstract. An alternative approach for the analysis of quantitative data, obtained from functional measurements, has been developed. The method does not require conversion of the quantitative measurements into quantal data thus defining a threshold level of effect. This method describes a parameter, equivalent to an iso-effective dose, which can be used for the comparison of different fractionation schedules by the assessment of lung function in radiobiological studies. The method only requires the use of a standard linear regression analysis and is therefore very simple to use.

The objective of many radiobiological studies is the comparison of the results of different treatment schedules. For such a comparison, iso-effective doses have to be established. Estimates of LD_{50} values, from lethality experiments, have long been used to assess the response of total body irradiation or the response of a vital organ with a specific latent period after irradiation (Field et al, 1976; Vegesna et al, 1985). The data obtained from lethality experiments are quantal (an all-or-nothing response). Apart from the ethical limitations of lethality experiments the dose dependence of this type of data can be legitimately described by either logit or probit analysis (Finney, 1964; Armitage & Berry, 1987). However, there are other methods of assessing radiation-induced damage from experimental studies which produce quantitative data. For the lung these include function tests, breathing rate, the measurement of biochemical parameters etc. These measurements usually describe the gradual variation in the measured quantity, prior to and after irradiation. Unfortunately, estimates of iso-effective dose, for different treatment schedules, cannot usually be obtained in an objective way from these data and consequently a sound statistical comparison of different schedules cannot be undertaken using standard statistical methods.

Various methods have been applied to the analysis of quantitative data. A statistically valid method is to convert quantitative data into quantal data by scoring the number of cases in each dose group that exceed a given threshold level of effect. This is usually greater than twice the standard error of the mean value of the quantity measured in unirradiated animals. For example, iso-effective doses can be obtained from breathing rate measurements in mice after converting the quantitative data into quantal data by setting a $\geqslant 20\%$ increase in breathing rate as a threshold level of response (Parkins et al, 1985). Similarly, the quantitative data obtained from studies of the gas exchange capacity of pig lung were converted into quantal response by setting a threshold level of effect of $\geqslant 15\%$ reduction in lung function (Rezvani et al, 1989). These quantal data were analysed by logit or probit analysis and iso-effective doses were obtained for each fractionation schedule. Reciprocal iso-effect doses were then plotted against dose per fraction (Douglas & Fowler, 1976) and dose fractionation parameters obtained. However, this is not a truly direct method of analysis and the definition of the threshold level of effect can be arbitrary. Thames et al (1986) have suggested a direct method of analysis in which raw data from different fractionation schedules were included in a single maximum likelihood treatment. This method might be superior to the two-step method, particularly with regard to error estimation, but since it was applied to quantal data it did not rectify the uncertainties associated with the choice of the threshold level of effect. Both methods can be criticized for not discriminating the severity of the response. McCullagh (1980) has proposed a generalization of the ordinal response in which a number of thresholds were established and each animal was scored according to whether its reaction level exceeded the defined threshold levels. Likelihood analysis was used to estimate a separate constant for each threshold level of effect and, naturally, the method was more complex than the usual logit or probit analysis, which is normally done for a single threshold level of effect. Taylor (1987) described how this method can be applied to radiobiological data, and it has been used by Vegesna et al (1988).

An alternative approach by which functional data can be analysed is proposed below. Figure 1 illustrates a typical cell survival curve obtained after single, acute doses of radiation (curve A). When each dose is divided into smaller fractions of equal size (d), the response can be depicted as curve B. This assumes that each fraction is delivered on different occasions, with the interval between doses being long enough to allow for the complete repair of sublethal damage, redistribution and normal progression of the cells in the cell cycle. In curve B, each equal but repeated fraction reduces the survival

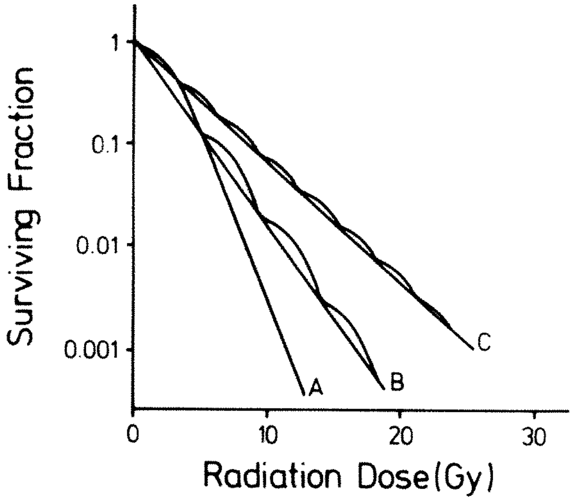

Figure 1. Idealized cell survival curves: A, after single doses of radiation; B, after N_1 fractions of size d_1; C, after N_2 fractions of smaller size d_2. ($N_2 > N_1 > 1$ and $d_2 < d_1$). Redrawn from Withers & Peters (1980).

by the same proportion (equal effect per fraction). The net cell survival curve obtained after fractionated irradiation can be represented by joining the survival levels after each fraction. This will be a mono-exponential function of dose which will appear as a straight line on a semilogarithmic plot. The slope of this line, which represents the effectiveness of fractionated radiation, is characteristic of a particular fraction size. If the doses are further divided and delivered in smaller dose fractions the total dose to produce the same effect will increase (curve C). The net survival curve after such a fractionated schedule will be shallower and consequently the slope of the line is reduced. This was very well demonstrated (Fig. 2) in the study of surviving cells per jejunal circumference after cobalt irradiation of mice (Withers et al, 1974).

The function of a given tissue is dependent on the interaction of a variety of cell types within that tissue. After radiotherapy, the change in tissue function will be proportional to the number of surviving cells, determined by total radiation dose, overall treatment time and dose per fraction. Unfortunately, the exact relation between the number of surviving cells and the change in tissue function is not known. However, the linear relation between the reciprocal total dose and dose per fraction described by Douglas & Fowler (1976), on the basis of cell survival, has been applied extensively to functional data by radiobiologists. This might suggest that in the absence of a comprehensive model radiobiologists have adopted a one-to-one relation between the cell survival and the loss of function by a tissue.

Assuming that the progressive reduction in the function of a certain tissue after irradiation is a reflection of the proportion of the potential target cells killed by radiation (van den Brenk, 1971; Thames & Hendry, 1987), the variations in the severity of function loss after each fractionation scheme might be described in terms of the resulting target cell(s) depletion. The proportional amount of function lost, per unit dose, for each fractionation scheme would be equal to the slope of a regression line fitted through the relative change in function of a tissue, at a certain time after irradiation, *versus* dose. This is illustrated in Fig. 3; by decreasing the dose per fraction, the proportional amount of function loss per unit dose (the slope of the regression lines) was reduced with the same trend as shown in Fig. 1. Assuming that an iso-effective reduction in tissue function is equivalent to an iso-survival of target cells, the proportional amount of function loss, per unit dose, can be taken as a parameter representing the effectiveness of a certain fractionation schedule. The inverse of this slope will be the radiation dose (Gy) required to produce a 67% loss in function, which would concep-

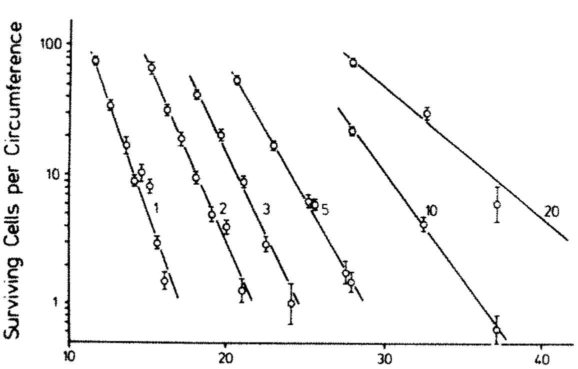

Figure 2. Survival of functional cells after 1–20 fractions of γ rays in mice. The slope of the survival curve was reduced with the increased number of fractions, indicating the reduced effectiveness of the radiation. Redrawn from Withers et al (1974).

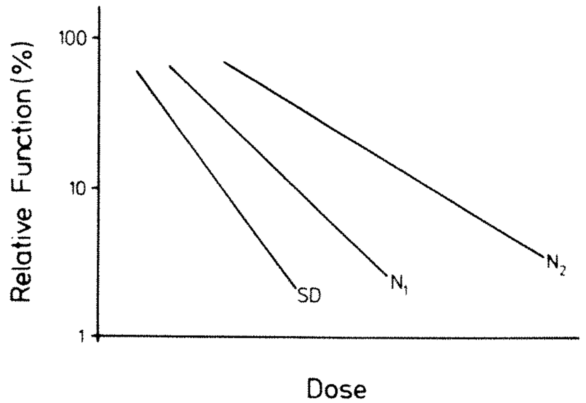

Figure 3. Hypothetical regression lines fitted through relative function (irradiated/control) of a tissue *versus* dose after single dose (SD), N_1 fractions of size d_1 and N_2 fractions of smaller size d_2. ($N_2 > N_1 > 1$ and $d_2 < d_1$).

Table I. ED_{50} values ($\pm$SE) for a $\geqslant 15\%$ reduction in lung function in the pig, assessed between 13 and 26 weeks after irradiation, for different fractionation schedules (data from Rezvani & Hopewell, 1989)

Fractionation schedule	$ED_{50} \pm$SE (Gy)
Single dose	10.12 ± 0.33
6F/39 days	22.53 ± 4.13
14F/39 days	27.55 ± 3.08
18F/39 days	40.63 ± 3.05
30F/39 days	45.29 ± 3.95

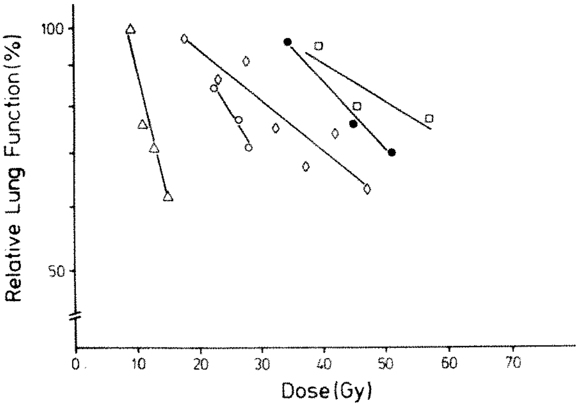

Figure 4. Relative lung function in pigs after irradiation with different fractionation schedules. △, single dose; ○, 6F/39 days; ◇, 14F/39 days; ●, 18F/39 days; □, 30F/39 days. The slope of the fitted regression line decreases with increasing number of fractions.

tually be similar to iso-effective doses. These in turn can be used to compare the effectiveness of different irradiation schedules.

In order to test the validity of this hypothesis, part of the results of an extensive fractionated irradiation study on pig lung (Rezvani & Hopewell, 1989) were reanalysed using this new approach and the findings compared with those of the previous analysis.

Method and materials

Data taken from a previously published study were used in this investigation. Although a detailed description of the experimental procedures was given previously (Rezvani & Hopewell, 1989) these are described briefly below. Changes in the relative function of the lung of pigs were studied after irradiaiton with single doses of ^{60}Co γ rays and fractionated doses of X rays given in 6, 14, 18 or 30 fractions over 39 days. The values of relative lung function were assessed between 13 and 26 weeks after irradiation. These data were then analysed on the basis of the hypothesis described above. A straight line was fitted to the log of the relative lung function (%) *versus* the radiation dose for each fractionation schedule. The inverse of the slope of this line was taken as the iso-effective dose.

The ED_{50} values obtained from the previous probit analysis (Rezvani & Hopewell, 1989), and the iso-effective doses obtained from the present study, *versus* number of fractions were plotted on a log–log scale and a separate regression line was fitted to each set of data.

Results

The ED_{50} values ($\pm$SE) for a $\geqslant 15\%$ reduction in lung function for different fractionation schedules obtained from Rezvani and Hopewell (1989) are listed in Table I. The ED_{50} values increase with increasing number of fractions, indicating the reduced effectiveness of the radiation dose. The average reductions in function of the irradiated lung, compared with the unirradiated lung, after irradiation with different fractionation schedules are shown in Table II. When these values were plotted on a semilogarithmic scale against total dose (Fig. 4), the resulting dose–effect curves were linear and had an appearance similar to that suggested previously on a hypothetical basis (Fig. 3). The slopes obtained from the different regression fits and their correlation coefficients are given in Table III. In four out of the five cases the slope decreased with an

Table II. Relative dose-related changes in lung function ($\pm$SE) of the irradiated region of pig lung compared with a comparable region of unirradiated lung averaged over the period 13–26 weeks from the mid-point of irradiation

Single dose		6F/39 days		14F/39 days		18F/39 days		30F/39 days	
Dose (Gy)	% lung function	Dose (Gy)	% lung function	Dose (Gy)	% lung function	Dose (Gy)	% lung function	Dose (Gy)	% lung function
9.0	100 ± 2	22.53	84 ± 10	17.86	97 ± 6	34.56	96 ± 3	39.36	95 ± 3
10.9	76 ± 2	26.50	77 ± 7	22.73	88 ± 4	44.93	76 ± 7	45.31	80 ± 6
12.8	71 ± 2	27.92	71 ± 7	27.60	91 ± 3	50.11	70 ± 7	56.96	77 ± 9
14.7	62 ± 3			32.47	75 ± 3				
				37.34	67 ± 2				
				42.20	74 ± 3				
				47.08	63 ± 3				

Table III. Absolute values of the slopes (±SD) of regression lines fitted to plots of the log of relative lung function *versus* dose and their reciprocal, *i.e.* iso-effect, doses (±SD) in Gy (the correlation coefficients of the regression lines fitted through the data points are also given for each fractionation schedule)

Treatment schedule	Slope ± SD (Gy^{-1})	Iso-effect dose ± SD (Gy)	Correlation coefficient
Single dose	0.079 ± 0.015	12.7 ± 2.4	-0.96
6F/39 days	0.029 ± 0.007	34.5 ± 8.3	-0.97
14F/39 days	0.014 ± 0.003	71.4 ± 15.3	-0.92
18F/39 days	0.021 ± 0.002	48.5 ± 4.6	-0.99
30F/39 days	0.011 ± 0.006	93.5 ± 51.0	-0.86

increasing number of fractions. For each fractionation schedule, the inverse of the slope of the regression line was taken; this represents the radiation dose in Gy associated with a 67% loss of function, *i.e.* iso-effective doses. When these doses were plotted against the number of fractions on a log–log scale (Fig. 5), a straight line with a slope of 0.56 ± 0.08 was obtained. This figure also shows the log–log plot of the ED_{50} values (Table I) against total dose and the fitted regression line. The slope of the line fitted to these data points was 0.44 ± 0.04. The difference in slope resulting from these two methods of analysis was not significant ($p > 0.1$).

Discussion

An alternative parameter has been proposed which can be obtained directly from quantitative functional data for the lung. This parameter was independent of any threshold level of effect and reflected the effectiveness of the radiation schedules. Using this parameter, the effectiveness of different fractionation schemes could be compared by the application of standard linear regression analysis.

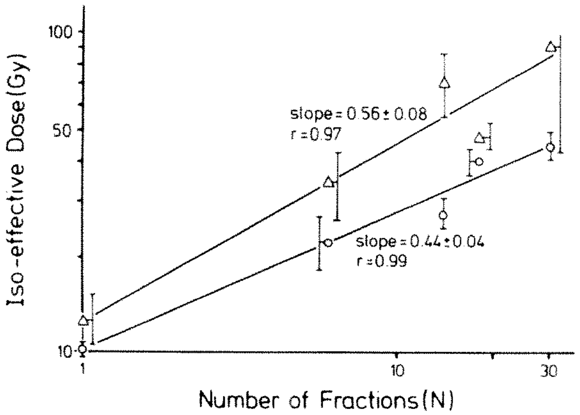

Figure 5. Iso-effective doses (△) from the present analysis and previous probit analysis (○) (Rezvani et al, 1989) *versus* number of fractions. The slopes of the regression lines fitted to these sets of data were not significantly different.

The slope of the line fitted to the iso-effect dose *versus* number of fractions in log–log scale for the present data was not significantly different from that obtained using probit analysis. However, if the linear-quadratic model were applied to these data a difference in slopes in the direction indicated by Fig. 5 would be expected, because the dose per fractions from the present analysis were larger than those obtained from previous ED_{50} values. However, in a previous paper (Rezvani & Hopewell, 1990), values of the α/β ratio obtained from a plot of iso-effect dose *versus* dose per fraction were very susceptible to the single-dose data point. Without the single-dose data the α/β ratios were not significantly different from zero, and Tucker's test (Tucker, 1984) indicated that the linear quadratic model could not adequately describe the data, of which the present data are a subset.

McChesney et al (1989) reported that the relative alveolar air space was reduced with increasing radiation dose in the dog, that the rate of reduction in alveolar air space was greatest after larger dose fractions and that the results could be fitted by straight line. These authors plotted their results on a linear scale; however, owing to the small range of change in alveolar air space with dose, plotting on a semilog scale would not significantly alter this trend although the slopes of the fitted lines might change slightly.

Ward et al (1985) have demonstrated that changes in lung perfusion and angiotensin converting enzyme activity after irradiation of rat lung could also be fitted very well by a line. However, these results showed a whole-organ dose–response relationship shallower than predicted by endothelial cell survival data. These data were based on clonogenic assays *in vitro* (DeGowin et al, 1976) or proliferation assays *in vivo* (Reinhold et al, 1985). This disparity could be due to the multiplicity of the target cells, or be due to a possible intrinsic mechanism in organ level which might be lacking in a tissue culture, or be because the maintenance of organ function is related to subclonogenic cell proliferation as was proposed by Reinhold et al (1985). In general, it is suggested that the response of an organ in an *in vivo* situation will be influenced by many different factors and therefore the following points should be considered.

(1) The data analysed in this paper were those of a slowly proliferating tissue. The treatment time was kept constant for all fractionation schedules and the interfraction time period was long enough to allow for the complete repair of sublethal damage. It must be borne in mind that the effectiveness of different treatment schedules might be influenced by the difference in repopulation kinetics as well as by cellular repair process.

(2) In complex organs, function is a result of interaction of more than one cell type and therefore a loss of function cannot be attributed to a single target cell population. Considering that each cell type has its own survival characteristics, a reduction in function might be explained in terms of the survival of certain

functional units rather than that of individual cell types responsible for the function of the organ. Clearly, the slopes of the lines fitted through the functional data of such organs will demonstrate a slope different from those of the cell survival curves of any of the possible target cells.

(3) In the study of paired organs, it is where one organ is irradiated and its function is assessed by comparing it with that of its unirradiated counterpart, that care must be taken, because of the fact that, owing to the activation of the compensatory mechanism which is usually triggered after the irradiation of one of the paired organs, the response of the unirradiated organ is not "normal". As the compensatory response is not yet well understood, data obtained from such experiments must be handled more cautiously. For this reason, in the present study only half of the left lung was irradiated. In this case the compensation would mainly occur at the upper lobe of the left lung rather than the contralateral lung (Rezvani et al, 1989).

Acknowledgments

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Technical notes

Occupational exposure and the Central Index of Dose Information

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Occupational exposure to ionizing radiation in the UK is presently controlled by the Ionizing Radiation Regulations, 1985 (Parliament, 1985) which were based on the recommendations of ICRP Publication 26 (ICRP, 1977). These recommendations and, in particular, the dose limits were formulated in the light of contemporary information about the risks of ionizing radiation (UNSCEAR, 1977). Recently, new epidemiological analyses of the survivors of the atomic bombs at Hiroshima and Nagasaki have been published (UNSCEAR, 1988; National Academy of Sciences, 1990). These studies suggest that the risk estimates for low doses and low dose rates may be higher by a factor of about 3 than previous analyses had indicated (Stather et al, 1988). In the light of preliminary announcements of the re-analyses of the atomic bomb survivors (*e.g.* Preston & Pierce, 1987) and of the ICRP Como Statement (ICRP, 1987), the NRPB recommended that occupational exposure to ionizing radiation should be controlled so as not to exceed an average dose equivalent of 15 mSv per year (NRPB, 1987). This has prompted renewed interest in the levels and distribution of occupational exposure to ionizing radiation.

This paper is based on a talk to the meeting organized by the British Institute of Radiology in December 1989 to discuss the implications of the new risk estimates. It presents statistics on occupational exposures in the UK in recent years and discusses the role of the Central Index of Dose Information (CIDI). The CIDI was set up by the Health and Safety Executive (HSE) under the 1985 Regulations; it fulfils a number of functions, including the provision of dose statistics. It is operated by NRPB, on behalf of HSE, from the Board's headquarters at Chilton.

Occupational exposure to ionizing radiation

The NRPB publishes periodic reviews of the radiation exposure of the UK population. The latest of these (Hughes et al, 1989) discusses, *inter alia*, occupational exposure in the late 1980s. In addition to this overview, a number of more specialized reports have been published, for example, describing the population of radiation workers for whom NRPB keep dose records (Best et al, 1990).

Hughes et al identified approximately 260 000 workers exposed to radiation in the course of their work and for whom dose estimates could be made. The numbers of workers, collective doses and mean doses by broad occupational group, for the year 1987, are shown in Table I. These data differ slightly from those published for the same period in Hughes et al (1989) since it has been possible to incorporate some more recent data.

About 60% of those listed are occupationally exposed to man-made sources of radiation. In most cases, the exposure is to external photon irradiation and it is likely that the dose assessment (by TLD or film badge) will be conservative, *i.e.* overestimate the doses actually incurred. A minority of workers, chiefly in the nuclear industry, also receive doses from radionuclides within the body and in these cases a contribution from committed effective dose equivalent, as assessed from monitoring data, has been included. In many cases, it is difficult to make accurate estimates of the doses from low levels of internal emitters. However, the contibution to the overall collective dose from this source is not large (about 5%).

Individuals working in the nuclear industry receive the largest mean doses and the majority of the collective occupational dose from man-made sources of radiation (69%). About 2% of these workers exceeded 15 mSv in the year. Fuel reprocessing involved the highest doses, though here, and in the nuclear industry generally, doses have been decreasing in recent years. In particular, the fraction of workers exceeding 15 mSv in a year is declining (Best et al, 1990).

Attention has recently been drawn to the importance of natural sources of radiation (Clarke & Southwood, 1989). In particular, it should be noted that about 40% of those exposed to radiation in the course of their work are exposed only to natural sources and that these individuals receive over half the collective dose from all sources of occupational exposure. In fact, the contribution of natural radiation is probably larger than figures in Table I would suggest. It is highly probable that significant numbers of people working in shops and offices in radon-prone areas of the country receive doses comparable with those in the Table (Hughes et al, 1989). However, the data are too scanty at present to allow the number of individuals or collective doses to be estimated and the problem is being tackled at source to reduce or eliminate any radiological hazard.

Aircrew are exposed to increased levels of cosmic radiation because aircraft travel at altitudes at which the

Table I. Summary of occupational exposure in the UK (updated from Hughes et al, 1989)

Type of work	Total number of workers*	Workers exceeding 15 mSv per annum*	Annual collective dose (man Sv)	Average annual dose (mSv)
Nuclear industry				
Fuel fabrication	3 000	70	10	2.8
Fuel enrichment	1 000	0	0.2	0.2
Fuel reprocessing	9 000	630	39	4.2
Power stations	23 000	60	18	0.8
Research	9 000	330	25	2.7
All nuclear industry	46 000	1100	92	2.0
Defence	17 000	100	16	1.0
General industry	21 000	100	13	0.6
Tertiary education	13 000	0	1.3	0.1
Health				
Medical	40 000	<10	8.4	0.2
Dental	20 000	0	2.0	0.1
Veterinary	4 000	0	0.4	0.1
All health workers	64 000	<10	10.8	0.2
Natural				
Coal mines	81 000	50	96	1.2
Non-coal mines	2 000	500	28	14.0
Aircraft crew	20 000	<10	40	2.0
All natural exposures	103 000	550	164	1.6
Total*	260 000	2000	300	1.1

* Rounded.

residual atmosphere provides limited shielding. The estimated mean dose (2 mSv) is similar to the mean for the nuclear industry. Coal miners are estimated to receive a mean annual effective dose from radon of about 1 mSv. Radon doses in non-coal mines are substantially higher: the mean annual dose is estimated to be 14 mSv, although the number exposed is much lower than in coal mines. It should be noted that all doses to miners discussed here are from radon only. It is likely that the inclusion of other sources of natural radiation underground (mainly γ irradiation) would increase mean annual doses by perhaps 2 mSv in some mines (Dixon et al, 1984).

The Central Index of Dose Information

The statistics described above on occupational exposure to radiation relate to doses incurred in a single year. An investigation of patterns of dose incurred over longer periods, and indeed regulatory control of such doses, requires that the dose records for successive occupations should be correlated. Up to the time of the 1985 regulations the mechanism for passing on dose records from one employer to the next involved a paper "transfer record". This proved error-prone and unreliable and considerable discussions were held during the preparation of the 1985 Regulations to evolve a better system. The proposal which was eventually adopted was named the Central Index of Dose Information or CIDI (Kendall et al, 1983). The CIDI would store details of all radiation workers who are required by the Regulations to be classified or subject to approved arrangements for dose assessment. The Approved Dosimetry Services (ADSs) responsible for day-to-day monitoring would send the CIDI summaries of dose for classified persons at the end of each year and also when a worker left classified employment. When an ADS started to keep records for an individual they would approach the Index to see if a dose history already existed. The exchange of information between ADSs and the CIDI is outlined in Fig. 1 and further details can be found elsewhere (Kendall et al, 1987; Greenslade et al, 1989).

The CIDI is presently being used to correlate the retrospective data transmissions from ADSs from the start of the Regulations and its first statistical reports can be expected shortly. Nevertheless, it is clear that the

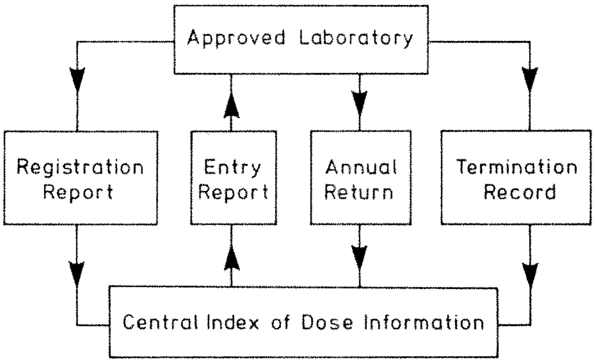

Figure 1. Exchange of information between the CIDI and Approved Dosimetry Services.

full worth of the CIDI will become apparent only when data for several years have accumulated and time trends in dose for individuals and groups can be investigated. One particular problem, implicit in the recommendations of ICRP Publication 26 and highlighted by the NRPB recommendations of NRPB-GS9, is the extent to which individuals may be "dose prone". Distributions of annual doses to radiation workers are typically found to be very skew with the large majority receiving low doses and a small minority in the high dose tail of the distribution. In these circumstances, the mean annual dose is low and the lifetime dose to an individual will also be low if doses are not correlated from year to year. A dose-prone individual, however, is one who consistently falls in the high dose tail of the distribution. A preliminary investigation of datasets from a number of countries suggested that, in some areas of work, dose-prone individuals could be identified (Johnston et al, 1986). If this proves to be the case in the UK, action will need to be taken to ensure that long-term mean doses for such individuals remain within acceptable bounds.

It is impossible to predict the full range of questions which the CIDI will be called upon to answer. However, it seems certain that there will be interest in groups receiving high doses, both in a given year and over a lifetime. There will also be an interest in time trends in doses and, perhaps, also in variations with age and sex of the worker. The latter would be required for detailed assessment of the detriment from occupational exposure to radiation.

Acknowledgments

Both the collection of comprehensive dose statistics and the planning and operation of the CIDI have involved too many individuals to be acknowledged individually in a short paper. We would like to thank all those involved, many of whom authored, or were acknowledged in, the references cited below.

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Recent films and screens for mammography

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Comparisons of various film–screen combinations for mammography have been reported in a series of communications, the most recent being one by Law and Kirkpatrick (1990). A further short series is reported here. The technique is unchanged from before. A phantom of "Barts" type (White & Tucker, 1980) with realistic details is used, and films are exposed in evacuated plastic envelopes to avoid any complicating influence from cassette design. The X-ray set used was a CGR 600T with molybdenum target and filter, but in this series all films were exposed at 28 kV with grid (rather than 25 kV, no grid, as before) in line with current clinical practice. All films were contact films at 60 cm focus–film distance (FFD) and were processed by a Dupont-T5A processor at 3.5 minutes, 35°C, and using Kodak chemistry.

New films considered were Fuji MA, Agfa MR3 II, CEA CM16 and Cronex Microvision. New screens were Fuji Fine and Agfa Detail (latest version available in summer 1989). As a basis for comparison, MinR films and screens were used as before, supplemented by Fuji NH film and Hi-Mammo screens which were identified as the best for image quality in our previous work. In addition, the Siemens Orthex MA screen was included because CEA recommend it for use with their film.

All films were taken using manual exposure control, and not automatic. The mAs value was selected to give a mean background film density under the phantom between 1.2 and 1.4, instead of 1.0 as in the past. Relative speeds were calculated by estimating the mAs required to give a density of 1.3. Films were exposed in sets of six taken under identical conditions, and the mean image score was calculated with the standard error (68% confidence limit). Many of the film–screen combinations were repeated on several days, and an overall mean and standard error were calculated. Films were scored by one physicist and one radiologist, and results combined as before (Kirkpatrick & Law, 1987).

Results for image quality are shown in Table I. It must be emphasized that with this phantom a small change in image score may represent a significant change in image quality; for example, a change of 1 kV in tube potential is likely to produce a change of 1.0 in image score (Law et al, 1989). Results for relative speeds are shown in Table II. On each day that films were obtained, one set was included using MinR film and screens as a reference. The variation between successive results with this combination was small.

On the whole, there is less variation in these results than in previous series. MinR remains the best film overall for image quality, but requires the highest dose. The Fuji Hi-Mammo screen appears to be the best screen, but Fuji have now withdrawn this, replacing it with their "Fine" screen which appears almost as good. This means that the Fuji NH–Hi-Mammo combination, previously recommended, is no longer available. Neither is the MA–Hi-Mammo combination, the best scoring one in this series. However, the Fuji MA film, supplied in June 1989, appears slightly better than NH film in this series, and rather better than a sample of MA film supplied in 1988. Of the combinations now available and requiring a significantly lower dose than MinR, the best seems to be Fuji MA film with Fuji Fine or MinR screens, or Agfa MR3 II film with Fuji Fine screens. The CEA film and the newest Agfa screen cannot quite compete against the others mentioned here, though both

Table I. Image scores from various film–screen combinations using a "Barts" phantom. (Numbers in brackets refer to the number of sets of films taken, six films per set)

Film	Screen				
	Kodak MinR	Fuji Hi-Mammo	Fuji Fine	Agfa Detail	Siemens Orthex MA
Kodak MinR	58.2±0.2 (8)	58.1±0.5	58.5±0.4 (2)	57.8±0.5 (2)	58.1±0.4 (2)
Fuji NH	56.5±0.8 (3)	58.1±0.3 (2)	57.3±0.4 (3)		
Fuji MA	57.6±0.6 (4)	58.7±0.4 (2)	57.7±0.4 (3)		
Agfa MR3 II	56.4±1.0 (4)		57.7±0.4 (3)	56.6±0.4 (2)	
CEA CM16	57.0±0.5 (2)		56.3±0.4		55.0±0.7
Cronex Microvision	57.1±0.4 (3)		56.9±0.6	55.8±1.0	57.7±0.5

Table II. Relative doses required for various film–screen combinations for a film density of 1.3

Film	Screen				
	Kodak MinR	Fuji Hi-Mammo	Fuji Fine	Agfa Detail	Siemens Orthex MA
Kodak MinR	1.00	0.99	1.03	0.89	0.95
Fuji NH	0.37	0.36	0.39		
Fuji MA	0.40	0.41	0.42		
Agfa MR3 II	0.40		0.40	0.36	
CEA CM16	0.43		0.43		0.42
Cronex Microvision	0.40		0.40	0.35	0.37

are better than a number of others in use. The CEA film performed better on MinR screens than on the Orthex MA screens chosen by CEA.

The Cronex film was the recently modified version "with improved visual clarity and static protection". This performed as well as the CEA film on MinR screens, and better than the CEA on the Orthex screens, where it may be as good as the others recommended here. Dupont are now using a new version of their screen in daylight cassettes. This screen is very white, similar in that respect to MinR screens, and very different from the Cronex Ortho Micro screen mentioned in previous work which was yellow. Dupont have not changed the name. It has not yet been possible to obtain loose specimens of these new screens, so they could not be included in this series.

If relative dose is considered, the majority of combinations are very similar. If the approximate doubling of dose can be accepted, then MinR film remains the best, whether on MinR, Fuji Fine or Siemens screens.

Acknowledgments

I am most grateful to Dr J. Walsh for scoring all the films, and to Dr A. E. Kirkpatrick for his comments. All the manufacturers referred to are thanked for supplying samples of their products.

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Case reports

The antenatal diagnosis of congenital cystic adenomatoid malformation of the lung

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Congenital cystic adenamatoid malformation (CCAM) is a rare pulmonary malformation characterized by the overgrowth of the terminal respiratory structures. Approximately 200 cases have been reported in the literature and the antenatal diagnosis by ultrasonography has been described in several case reports. We report two cases of this condition where the diagnosis was made antenatally. In the second case, the early diagnosis of the lethal microcystic form of the abnormality at a gestational age of 18 weeks allowed the elective termination of the pregnancy. This is the earliest diagnosis of this form of CCAM that has been reported.

Case reports

Case 1

A 28-year-old woman (gravida 3, para 1) was referred for a detailed antenatal scan after a scan at another hospital revealed multiple cysts within the right hemithorax. The detailed scan showed a single fetus of an estimated gestational age of 25 weeks (biparietal diameter, 6.8 cm; femur length, 4.5 cm; trunk circumference, 20.5 cm). There were multiple cysts in the right thorax with displacement of the mediastinum to the left (Fig. 1). There was no polyhydramnios or fetal hydrops. A differential diagnosis of diaphragmatic hernia or congenital cystic adenomatoid malformation of the lung was made. The baby was delivered vaginally at 36 weeks and was clinically well. A chest radiograph showed patchy opacification in the right lower zone, but there was no evidence of a diaphragmatic hernia. Repeat films taken over the next few weeks showed some clearing of the shadowing, and small cysts could be identified in the right lower zone (Fig. 2). The diagnosis of CCAM (macrocystic type) was made radiologically, but, as the child remained well, no further investigations or treatment were undertaken.

Case 2

A 32-year-old woman (gravida 3, para 1) was referred for a detailed scan after a routine scan at another hospital revealed a mass within the thorax. The detailed scan demonstrated a single fetus of 18 weeks gestational age (head circumference, 15.5 cm; femur length, 2.9 cm). There was a highly echogenic mass in the right hemithorax which contained a localized area of small cysts (Fig. 3). The rest of the fetal examination was normal with no evidence of hydrops, although there was mild polyhydramnios. The diagnosis of congenital cystic adenomatoid malformation of the lung of the microcystic type was made and, after the poor prognosis of this lesion was discussed with the parents, an elective termination of the pregnancy was performed.

A detailed pathological examination was performed soon after delivery. External examination showed the fetus to be female with no external morphological abnormalities. Internal examination was unremarkable except for the thorax, where the right lung had four lobes and the left three. The two upper lobes of the right lung had a more solid appearance than that of the other lobes. Midline shift was not detected, and the bronchi had a normal distribution.

Histologically, the lungs were at the cannulicular stage of development and the right upper lobes consisted of many small

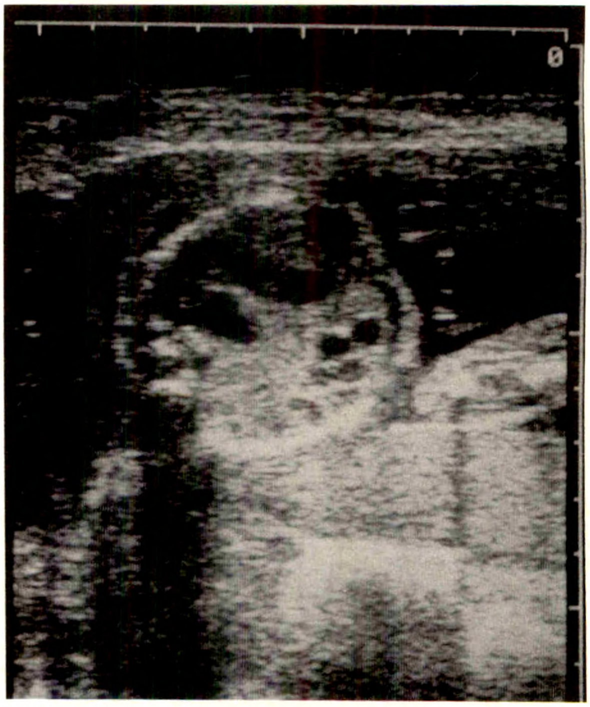

Figure 1. Scan showing cross-section of the fetal thorax with the heart anteriorly. Multiple cysts are seen posteriorly within the right hemithorax (CCAM macrocystic type).

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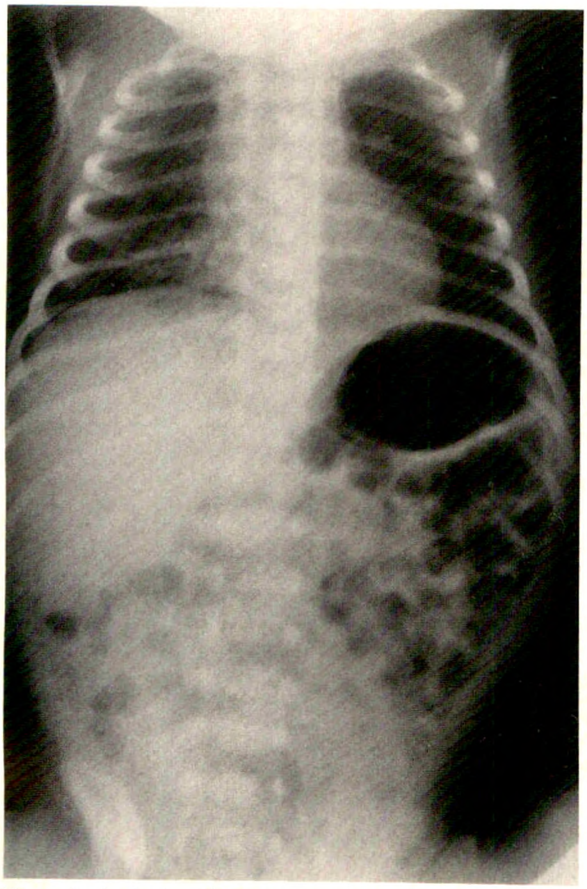

Figure 2. A chest radiograph taken several days after birth showing several cysts in the right lower zone (CCAM macrocystic type).

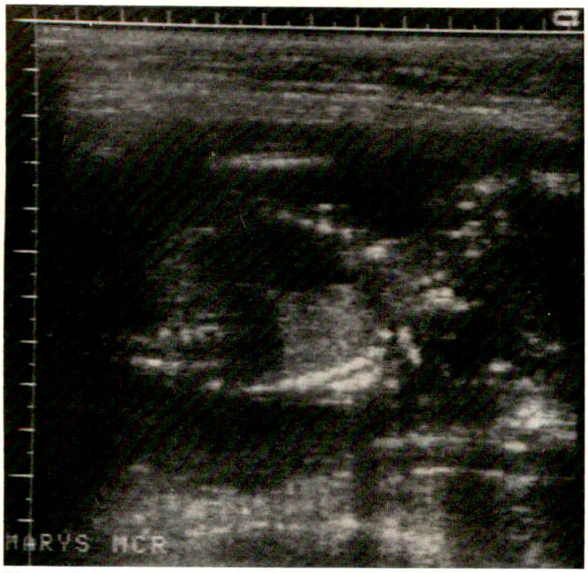

Figure 3. Scan showing the fetus in longitudinal section with the head on the right. The left hemithorax is occupied by a highly echogenic mass (CCAM microcystic type).

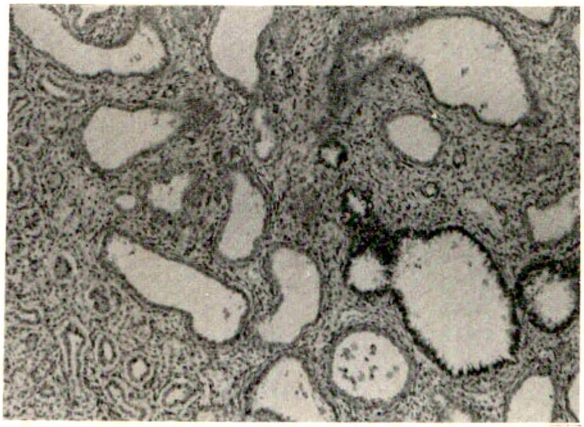

Figure 4. Section of lung parenchyma illustrating the interface between the normal tissue (left) and the area of CCAM (right). Two ducts reminiscent of bronchioles can be seen (right of centre) which are lined by a more hyperchromatic epithelium. Original magnification × 20.

cysts approximately 200 μm in maximum diameter. These cysts reached the pleural surface and were lined by a simple cuboidal epithelium. Occasional ducts reminiscent of bronchioles were present between the cysts. The abnormal pulmonary tissue blended into the adjacent normal lung parenchyma (Fig. 4). These appearances are those of Type II congenital cystic adenomatoid malformation.

Discussion

Congenital cystic adenomatoid malformation of the lung was first described as a separate pathological entity by Ch'in and Tang in 1949. It is characterized by an increase in the terminal respiratory structures forming cysts of variable sizes (Kwitten & Reiner, 1962). The lesion is usually unilateral, although bilateral cases have been reported (Morcos & Lobb, 1986). In 1977, Stocker et al classified the lesion into three types on the basis of cyst size. Type I has large thick-walled cysts, up to several centimetres in diameter, which may contain mucin-secreting cells in their walls, and there is usually communication between the cysts and the bronchial tree. In Type II, the cysts are smaller in size, up to 1 cm in diameter, evenly spaced and thinner walled. The abnormality usually blends gradually into adjacent normal lung. In Type III, the cysts are very small, less than 0.5 cm in diameter, and the abnormality usually affects the whole lobe.

The antenatal ultrasonographic appearances of this condition have been well described, both for Type I (Donn et al, 1981; Pezzuti & Isler, 1983) and Type III (Diwan et al, 1983; Cave & Adam, 1984; Johnson et al, 1984; Mendoza et al, 1986).

Adzick et al (1985) modified the classification into two groups according to the ultrasonographic appearances: macrocystic with cysts greater than 5 mm in diameter, visible ultrasonically as fluid-filled spaces, and microcystic with smaller cysts, appearing as a highly echogenic mass because of multiple reflective interfaces, similar to infantile polycystic kidneys. The prognosis of CCAM depends on the type of lesion, and associated polyhydramnios and hydrops fetalis are important prognostic indicators (Adzick et al, 1985).

Type I CCAM has the most favourable prognosis, as it is not usually associated with polyhydramnios or hydrops, although there is often mediastinal shift (75% in Stocker's series). The child may present in the neonatal period with respiratory distress or in later childhood with recurrent respiratory tract infections, and the abnormality has been reported as an incidental finding in asymptomatic adults (Madewell et al, 1975).

Type II has an unfavourable prognosis, as it is often associated with other anomalies such as renal dysplasis, cardiac abnormalities and small bowel atresias.

Type III also has a very poor prognosis, as this type is associated with polyhydramnios and hydrops, either together or independently. The mechanism of this is unclear, but is thought to result from the expanding mass causing compression of the inferior vena cava and the fetal oesophagus (Johnson et al, 1984). There is also usually hypoplasia of the other lung.

The differential diagnosis of the antenatal appearances of CCAM depends on the type. The macrocystic type may be diagnosed as a diaphragmatic hernia, although peristalsis of the bowel within the thorax may be detectable in this condition. The microcystic type has a highly echogenic appearance, which distinguishes it from the rare solid thoracic tumours. The main radiological differential diagnosis is extralobar pulmonary sequestration, but the presence of cystic elements and the association of polyhydramnios and hydrops makes the diagnosis of microcystic CCAM more likely. There has been a recent case report of these two conditions occurring together (Morin et al, 1989), but the presence of an abnormal blood supply to the affected lung is difficult to diagnose antenatally.

Case 2 is an example of the microcystic type of abnormality which was detected early in pregnancy at a baseline scan before the development of clinically detectable polyhydramnios. It was thought from the antenatal features to represent a Type III lesion, and on histological examination the cysts were very small, accounting for the echogenic appearance. However, the histological appearance of abnormal lung blending into normal lung is more characteristic of a Type II lesion. The earliest diagnosis of microcystic CCAM previously reported is a case of Type III CCAM detected at 19 weeks, in which the fetus had already developed ascites (Albright & Katz, 1989). This is the earliest reported case of the microcystic form of the abnormality presenting as an isolated finding on a routine antenatal scan, and the early diagnosis allowed the elective termination of the pregnancy.

In all cases where a pregnancy is terminated for a known fetal abnormality, the fetus should be submitted to a detailed pathological examination. This is not only to confirm the presence of the abnormality, but it also plays an important part in medical audit.

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Severe dwarfism with cataracts. A new osteo-chondrodysplasia

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We report the findings of a new osteo-chondrodysplasia which does not fulfil the diagnostic criteria of any previously reported dysplasia. Severe short stature, resulting from spine and rhizomelic limb shortening, and cataracts are associated with radiological abnormalities of the spine, epiphyses and metaphyses.

Case report

M.S. was born in 1973 in a village in Bangladesh. No measurements were made at birth but his mother says he was a little smaller than her three later born children. As a child he was always smaller than the other children but his short stature became more obvious with age and by the time he was 10 years old it was clear that he was severely short. When he went to the village school at the age of 5, poor vision was noted and subsequently he went to an ophthalmic service in Sylhet where bilateral cataracts were operated on with some visual improvement. No retinal abnormality was commented upon. He came with his mother and younger brothers to the UK in 1989 to join his father, who had been here intermittently since 1960. M.S. was then referred to R.F.F. because of his short stature.

He was a broad, muscular, post-pubertal 16-year-old boy of normal intelligence and hearing but with partial sight. The eyes showed clear ocular cornea, deep anterior chambers, and there were fairly dense posterior capsular remnants on both sides. His fundi showed no abnormality of retinae or optic nerves; an electroretinogram was normal. He was extremely short with a height of 99 cm (the mean height of a $3\frac{1}{2}$-year-old boy) because of shortening of both trunk and limbs (Fig. 1). Arm span was

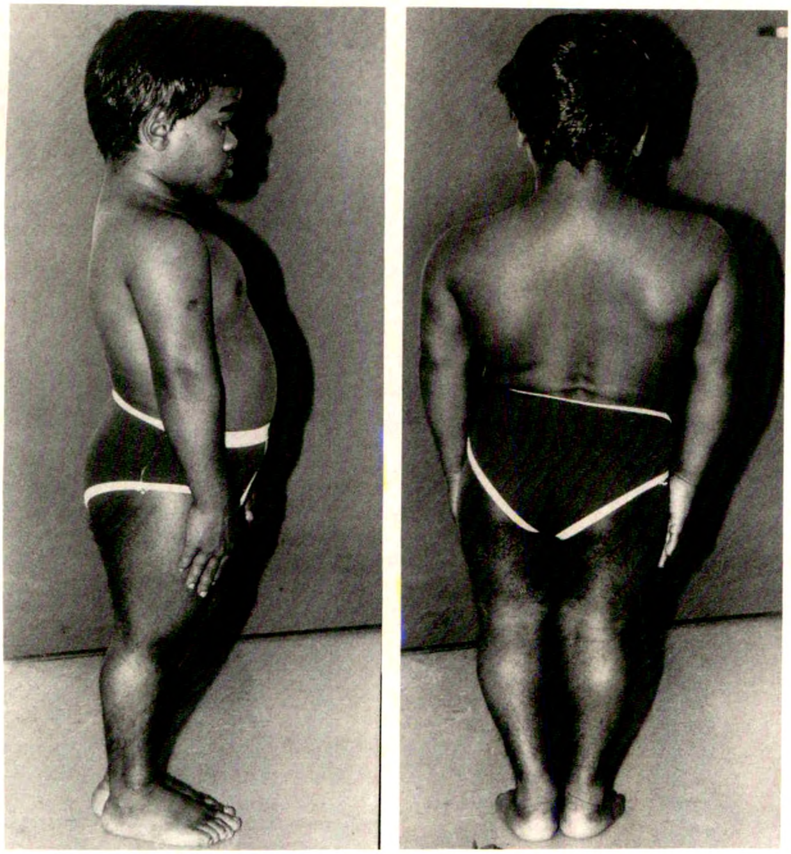
(a) (b)

Figure 1. (a) Lateral and (b) posterior views of the subject. Note the rhizomelic limb shortening, depressed nasal bridge and absence of scoliosis.

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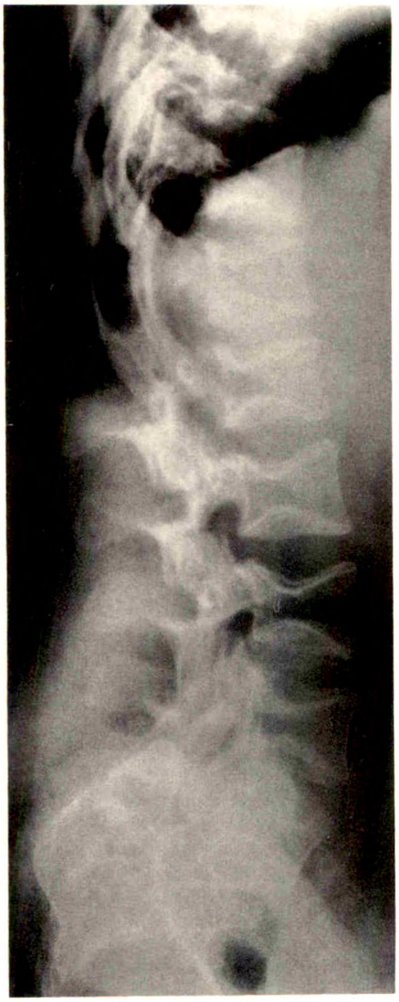

Figure 2. Mild platyspondyly, end plate concavities, lumbosacral lordosis and a short sacrum.

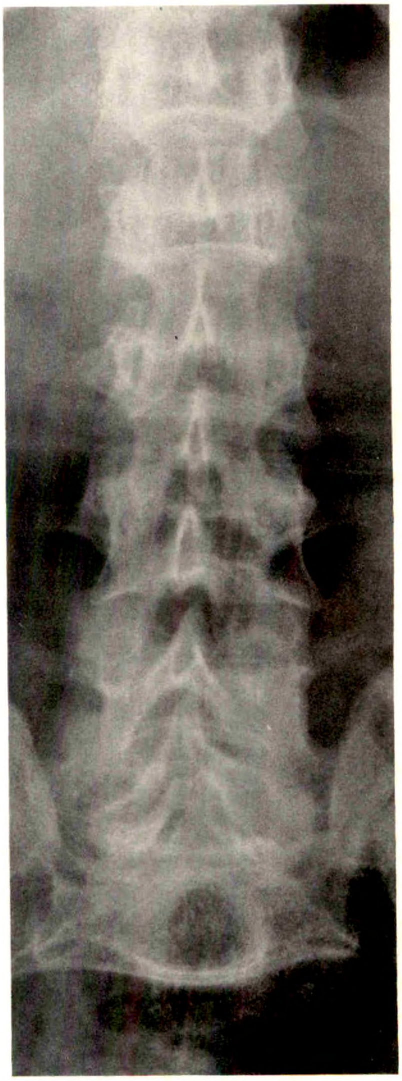

Figure 3. Interpedicular narrowing in the lumbar spine.

107 cm; upper segment height was 48 cm and lower segment height was 51 cm. The shortening of his limbs was mainly proximal, so that his upper arm measured 17 cm and his forearm 20 cm. There was 20° of limitation of extension at the elbows but his other joints were mobile and not hyperextensible. His hands, fingers and feet were all short, with his palm measuring 8.5 cm, his middle finger 5.5 cm and his feet 16.5 cm. His head circumference was 51 cm (70th centile for height). There was no scoliosis. M.S. had a broad, indented bridge to his nose but otherwise there were no other dysmorphic features, in particular no cleft palate or talipes.

His parents were 22 and 39 at the time of his birth; they were not consanguineous. There were three healthy younger brothers aged 14, 10 and 3 years.

Radiological findings

1. The spine showed a generalized platyspondyly with concave end-plate depressions centred toward the posterior third of the end-plate (Fig. 2). The pedicles were short and in the lumbar region there was progressive narrowing of the interpedicular distances (Fig. 3). The sacrum was low set, short and there was a marked lumbosacral lordosis. There was no instability at the atlanto-axial articulation.
2. The humeri were short and bowed (Fig. 4).
3. Short metacarpals and phalanges, pattern profile analysis revealed that the former were a little more severely affected than the latter (Fig. 5). The skeleton was mature.
4. Coxa vara with small femoral heads and marked overgrowth of the greater trochanters which articulated with the ilia (Fig. 6).
5. Square-shaped femoral condyles with striations within the metaphyses of the knees probably indicative

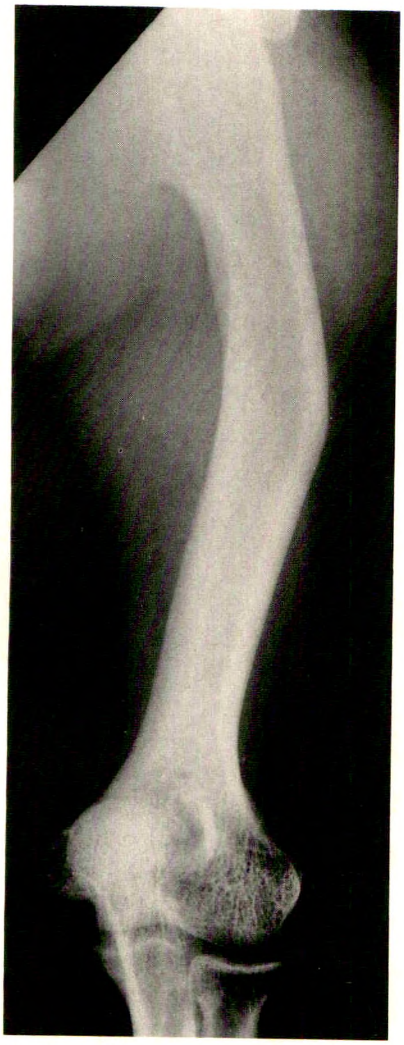

Figure 4. Short bowed humerus.

of a previously more obvious metaphyseal abnormality (Fig. 7).

6. Broad chest with normal ribs.
7. Normal skull.

Other investigations

Because of the patient's obvious sexual maturity and lack of clinical evidence of general disease, extensive investigations were not performed but the following were noted.

A full blood count was normal as was a biochemical profile including proteins, calcium, phosphate, alkaline phosphatase, serum electrolytes, creatinine and liver function tests. The serum total thyroxine was 93 nmol/l and the testosterone 19 nmol/l. Electrophoretic patterns of urinary oligosaccharides and glycosaminoglycans were normal. The electrocardiogram was normal.

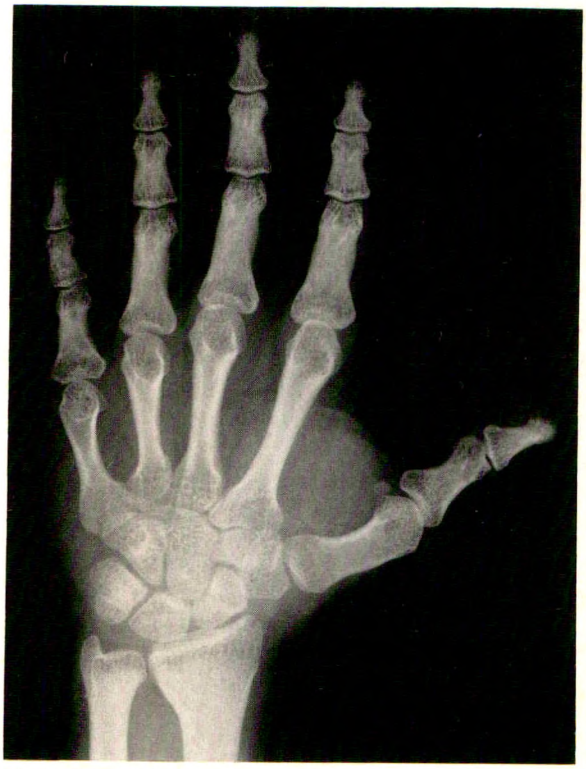

Figure 5. Hand showing metacarpal and phalangeal shortening.

Discussion

Clinically this condition has many of the features of spondyloepiphyseal dysplasia congenita (Spranger & Langer, 1970) but the patient does not have cleft palate, talipes, myopia or retinal detachment and the radiological features are not consistent with that diagnosis. The autosomal dominant type of chondrodysplasia punctata is characterized by a depressed nasal bridge, cataracts and scoliosis. Mental development is normal but adult height is usually above 130 cm and the overall radiological picture in our patient is not typical of that condition (Spranger et al, 1971). Marked symmetrical rhizomelia is a feature of the rhizomelic form of chondrodysplasia punctata (Heselson et al, 1978) and although the prognosis is poor, some individuals do survive into adulthood. However, the clinical presentation is obvious at birth and those who survive into adult life are severely mentally retarded and frequently show a scoliosis.

Narrowing of the interpedicular distances in the lumbar spine is a feature of a number of conditions, the most well known being achondroplasia, hypochondroplasia, diastrophic dysplasia, pseudohypoparathyroidism, Kniest syndrome and acrodysostosis. Achondroplasia and hypochondroplasia are excluded on clinical grounds. Diastrophic dysplasia (Lamy & Maroteaux, 1960) is accompanied by broadening of the trochanteric region but the femoral heads are flattened,

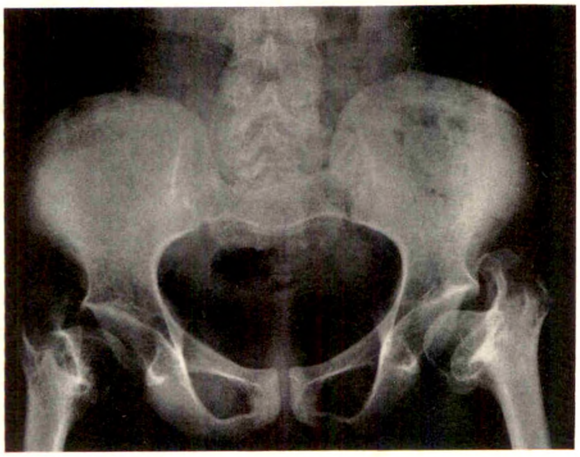

Figure 6. Anteroposterior pelvis showing small round femoral heads and marked overgrowth of the greater trochanters.

the spine is more severely affected and our patient does not have joint contractures, abnormal thumb, club feet or cleft palate. Shortness of stature is obvious at birth. Pseudohypoparathyroidism exhibits metacarpal shortening as the main radiological abnormality. The severe skeletal changes in this patient exclude that diagnosis. Severe shortness of stature with depressed nasal bridge, cataracts, platyspondyly and broad metaphyses are features of Kniest syndrome (Siggers et al, 1974) but signs are present at birth and joint stiffness and contractures with malalignment of joints are features not seen in our patient. Other features of Kniest syndrome, *i.e.* myopia, hearing loss and cleft palate, are also absent. Acrodysostosis exhibits distal, not proximal, limb shortening.

Opsismodysplasia (Maroteaux, 1984) is a condition recognized at birth on the basis of shortness, short hands and facial abnormalities with a short nose and a depressed nasal bridge. Many of the affected infants have died from respiratory problems but in older survivors dwarfism is severe. Radiological signs are very retarded skeletal maturation, extreme shortening of the bones of the hands and feet with concave metaphyses and thin vertebral bodies. Pedicles are normal and the lumbar spinal canal does not narrow caudally. Radiologically, therefore, the condition differs from that present in the case described here.

As the clinical and radiological features of M.S. do not fit any well defined skeletal dysplasia, we consider him to have a new condition. This might have resulted from a new dominant mutation in view of his father's age when he was born.

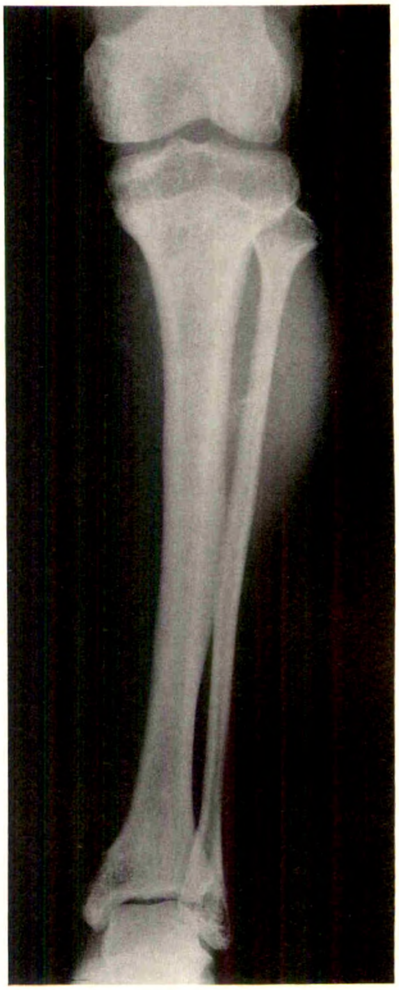

Figure 7. Left knee and lower leg. There are faint metaphyseal striations.

Acknowledgments

The authors are grateful to Dr Christine Hall at The Hospital for Sick Children, London for reviewing the radiology, and to Dr Peter Farndon for the clinical photographs. We thank Mrs Hasina Alam for her help as an interpreter and Mr Eamon O'Neill for his ophthalmological opinion.

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Paraganglioma of the duodenum: a case report with radiological findings and literature review

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Paraganglioma of the gastrointestinal tract is an uncommon, usually benign neoplasm. It usually occurs in the second section of the duodenum. A review of the literature reveals 73 reported cases. We studied a case of paraganglioma by hypotonic duodenography (HDG), computed tomography (CT), angiography and histological examination.

The rare occurrence of this neoplasm and the first comparative study using HDG, CT and angiography justify this case report.

Case report

A 65-year-old Japanese woman had been in excellent health until she presented to her physician with tarry stool. The bleeding site was not determined. Seven months later, she visited another physician because of general fatigue, and was found to be anaemic and bleeding from the gastrointestinal tract.

She was referred to the Kawasaki Medical School Hospital for further evaluation. On admission, she was moderately anaemic but not jaundiced. The abdomen was flat and soft without rebound tenderness. A slightly rough-surfaced, goose-egg sized mass was palpable in the right upper quadrant of the abdomen which moved with respiration but was not tender. Routine laboratory examination showed no abnormalities except anaemia.

A hypotonic duodenogram showed a relatively smooth-edged filling defect with a deep and irregular niche on the lateral wall of the second portion of the duodenum (Fig. 1).

Contrast-enhanced CT revealed an inhomogeneous mass of soft-tissue density along the lateral aspect of the duodenum. This study was carried out with Gastrografin so that the mass could be easily demonstrated (Fig. 2).

Common hepatic arteriography showed a hypervascular area with tortuous newly formed vessels derived from the superior pancreaticoduodenal artery (Fig. 3a). A late phase of this study revealed an inhomogeneous tumour stain outside the duodenum (Fig. 3b).

Superior mesenteric arteriography showed a hypervascular area fed from the inferior pancreaticoduodenal artery. These vessels fed the right lateral side of the tumour.

Based on these findings, a radiological diagnosis of malignant submucosal tumour of the duodenum was made.

At laparotomy, a circumscribed submucosal tumour of the duodenum was identified, extending through its wall. There was, however, no gross evidence of malignancy. A duodenotomy was performed. The post-operative course was uneventful, and she is still alive and free of recurrence 7 months after surgery.

Pathological examination revealed a 6.5 cm tumour located along the convex side of the second part of the duodenum opposite the ampulla of Vater, with extension through the duodenal wall. The outer surface of the tumour was dark violet-red, nodular and covered by the serosa-like capsule. Capillaries were engorged on and around the tumour. The cut surfaces of the tumour were soft and elastic and its luminal aspect was deeply ulcerated.

Microscopic examination revealed the cell nests to be composed of polygonal and spindle-shaped cells. The cell nests were surrounded by thin, delicate bands of vascular and reticular stroma. The overall picture was that of "Zellballen" (Fig. 4). The tumour cells contained abundant eosinophilic-staining cytoplasm; there were occasional mitoses; but there were neither vascular invasion nor lymph node metastases. Immunohistochemical stains were consistent with paraganglioma.

Discussion

Review of the literature reveals 73 cases of paraganglioma of the duodenum. Most patients were in their sixth decade of life (mean age, 51.4; range 15–80 years). The lesion was more common in men, with a male to female ratio of 1.8 : 1. The most common initial clinical manifestations were upper gastrointestinal bleeding or

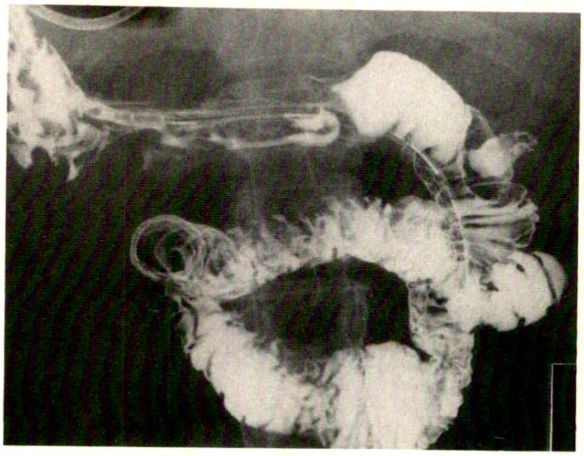

Figure 1. Hypotonic duodenography shows a relatively smooth-edged filling defect with a deep and irregular niche.

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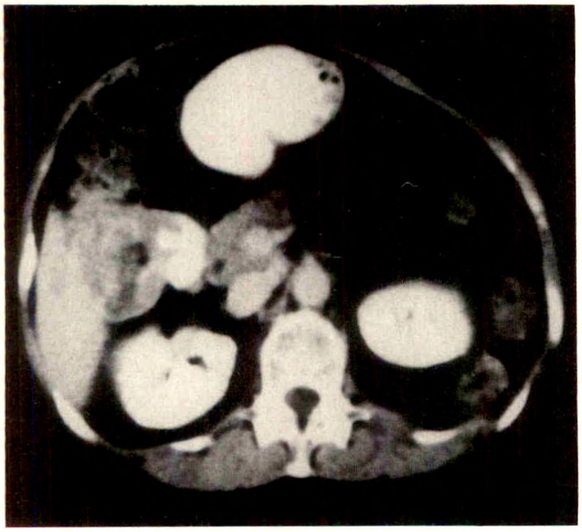


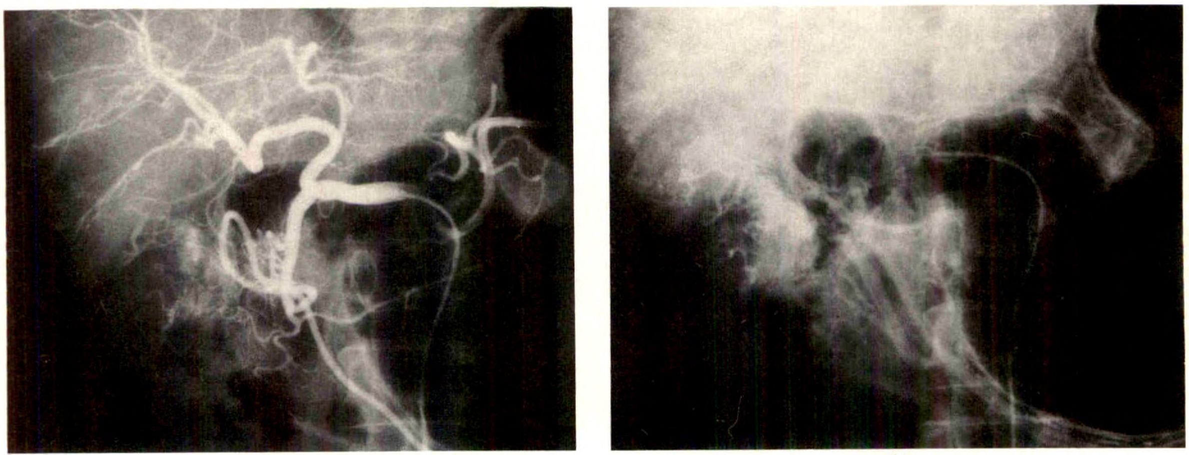
Figure 2. Contrast-enhanced CT reveals an inhomogeneous soft-tissue density mass.

melaena (47%), followed by abdominal pain (33%). Obstructive jaundice occasionally occurred in association with a periampullary lesion. Some patients remained symptom-free. There has, in general, been no known association between paraganglioma and other diseases; although a patient with paraganglioma and neurofibromatosis (Kheir & Halpern, 1984) and a patient with paraganglioma and duodenal adenocarcinoma (Anders et al, 1987) have been reported.

Barium swallow in patients with paraganglioma usually shows a small polypoid filling defect in the proximal small intestine and sometimes reveals a submucosal tumour-like shadow. Although many lesions are ulcerated, upper gastro-intestinal (GI) barium studies may reveal niches in only a few cases and the true nature is difficult to establish by barium studies alone. Further examination is, therefore, required. A review of literature revealed six cases examined by angiography and three cases by CT studies. Paraganglioma was demonstrated in four cases as a hypervascular lesion. One case showed an avascular lesion and another was negative by angiographic study. Computed tomographic studies revealed a soft-tissue mass in all cases. Our case showed a soft-tissue density with inhomogeneous contrast enhancement. There has been no study of paraganglioma by contrast-enhanced CT. Multiple paragangliomas have been reported (Williams et al, 1980; Egawa et al, 1986) and some developed outside the duodenum. In a case of multiple paragangliomas reported by Egawa et al (1986), one of the lesions could not be detected by either endoscopic studies or upper GI barium studies. In the case of a polypoid or submucosal tumour suspected as being a paraganglioma, CT studies should be carried out. Endoscopic examination usually reveals a submucosal expansile mass, occasionally with mucosal ulceration. Biopsy specimens usually yield mucosal fragments devoid of diagnostic histologic materials. It is, therefore, very difficult to assess paraganglioma by endoscopy.

Paraganglioma is, in general, a benign lesion and it is sufficient to excise the tumour locally together with lymph node dissection. However, there have been cases of malignant paraganglioma with lymph node metastases (Büchler et al, 1985; Anders et al, 1987). No recurrence of paraganglioma has been reported. The radiographic criteria of malignant paraganglioma should be established.

Most paragangliomas (89%) are found in the second parts of the duodenum and involve the ampullary region. The lesions have also been reported in the third and fourth parts of the duodenum (Beltrami et al, 1980; Shamsai et al, 1984; Scheithauer et al, 1986). All



(a)

(b)

Figure 3. (a) Common hepatic angiogram showing a hypervascular area with irregularly outlined new vessels derived from the superior pancreaticoduodenal artery. (b) Late phase shows a tumour stain.

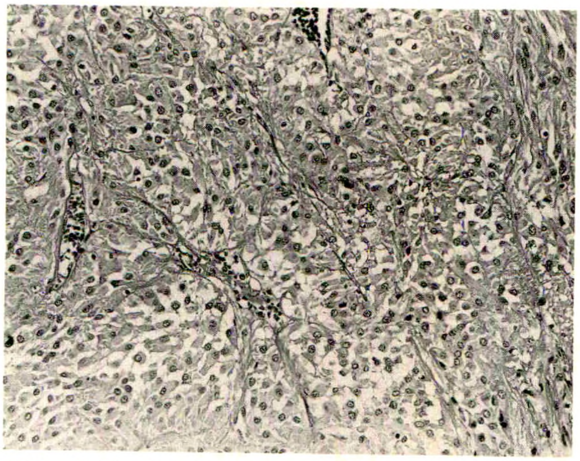


Figure 4. The tumour consists of groups of polygonal and spindle-shaped cells. The tumour cells show nests surrounded by thin, delicate bands of vascular and reticular stroma.

reported tumours are present along the medial aspect of the duodenum. Our case is unique in that a lesion was present in the lateral wall of the duodenum. Paragangliomas of the duodenum vary from 0.5 cm to 10 cm in maximum diameter (mean: 2.9 cm). Eighty-nine per cent of the tumours are smaller than 5 cm in diameter. The lesions were usually oval to polypoid and covered by an intact tan mucosa. Some tumours are submucosal, as in our case. Forty-six per cent of tumours have pedicles and 40% are ulcerated when they become large.

Depending on the predominant components of the tumour, various terminologies have been applied to the tumours derived from or associated with ganglion cells and related peripheral nerves. Fetuses and newborn babies show a more extensive distribution of paraganglion cells than adults. Glenner and Grimley (1974) assumed that there may be cellular nests during development that remain dormant in adults. It has also been suggested that visceral-autonomic paraganglia may be related to the vagal paraganglia (Coormaghtigh, 1936). Helpap (1978) reported extra-adrenal paraganglia and their tumours. Extra-adrenal paragangliomas originate, in more than 98% of cases, in a number of structures with a chemoreceptive function and are called "chemodectomas". Dahl et al (1957) were the first to describe a duodenal ganglioneuroma and drew attention to neurofibroma and delicate stroma with many ganglion cells. Taylor and Helwig (1962) found nine polypoid structures which they classified as non-chromaffin paragangliomas. In 1971, Kepes and Zacharias described two polypoid tumours of the duodenum which were termed gangliocytic paraganglioma. These tumours may be collectively described as paraganglioma of the duodenum, which encompasses a wide morphologic spectrum, ranging from non-chromaffin paraganglioma and gangliocytic paraganglioma to ganglioneuroma (Shamsai et al, 1984).

In conclusion, in a case of upper gastro-intestinal bleeding and duodenal polypoid lesion, paraganglioma should be considered in the differential diagnosis. Further examinations including CT and angiographic studies should be performed.

Acknowledgments

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The scintigraphic detection of ossific mediastinal and pulmonary metastases in osteosarcoma

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(*Received April 1990*)

Osteosarcoma primarily occurs in the metaphyses of long bones, and metastatic spread is generally hematogenous (Price & Jefree, 1973). While localized lymph node dissemination is frequent, spread to distant nodes is unusual. Detection of occult metastases can influence patient prognosis. This case demonstrates the sensitivity of scintigraphy in detecting ossific metastases not recognized on conventional radiography and not detected by computerized tomography (CT).

Case report

A 24-year-old man presented with pain and swelling in the region of the left knee. Plain radiographs demonstrated intense osteoblastic changes in the distal left femur; a radiological diagnosis of osteosarcoma was made (Fig. 1), which was confirmed histologically. Thoracic CT demonstrated no evidence of metastatic spread. Scintigraphy with $^{99}Tc^{m}$-MDP demonstrated focal intense uptake in the region of the tumour, but no evidence of satellite lesions.

The patient was treated with en bloc resection of the tumour, prosthesis insertion and chemotherapy. At restaging, 10 months after presentation, faint opacities were seen on a chest radiograph in the right upper hemithorax and were initially considered to be granulomata, in view of a history of previous primary tuberculosis (Fig. 2a). Bone scintigraphy demonstrated low-grade abnormal uptake in the opacities (Fig. 2b) indicating that they represented osteoblastic metastases. The lesions were not visible on thoracic CT and no mediastinal adenopathy was demonstrated.

Eighteen months after initial presentation, the patient complained of pain in both shoulders, tightness in the chest and occasional hoarseness. A chest radiograph demonstrated calcific nodules in the right lung, in the same distribution as the smaller nodules noted 8 months previously, and a large calcified mass in the mediastinum at hilar level extending into the left lung (Fig. 3a). Isotope bone scanning showed intense uptake in the mediastinum, lungs, ribs, skull, pelvis and femora consistent with extensive bone, lymph node and soft-tissue metastases (Fig. 3b). Computerized tomography of the thorax confirmed calcific metastases in both lungs and an extensive calcified mediastinal mass encasing the superior vena cava and extending into the left hilum and left anterior chest wall (Fig. 4a). A separate metastasis to the left side of the pericardium was also identified (Fig. 4b).

Discussion

Metastases from osteosarcoma spread hematogenously, most frequently involving the lungs (45% at autopsy), other bones (50% at autopsy) and the kidneys (12% at autopsy) (Goldstein et al, 1977).

Lymph node metastases from osteosarcoma have been reported only rarely, and most reports refer to the regional nodes draining the primary tumour. Madsen reported two cases of metastases in draining nodes visible as areas of ossification on plain films, and commented that ossified metastases visible on plain films probably occur only with the osteoblastic variety of osteosarcoma (about 50% of the total) (Madsen, 1979).

Involvement of mediastinal lymph nodes is very

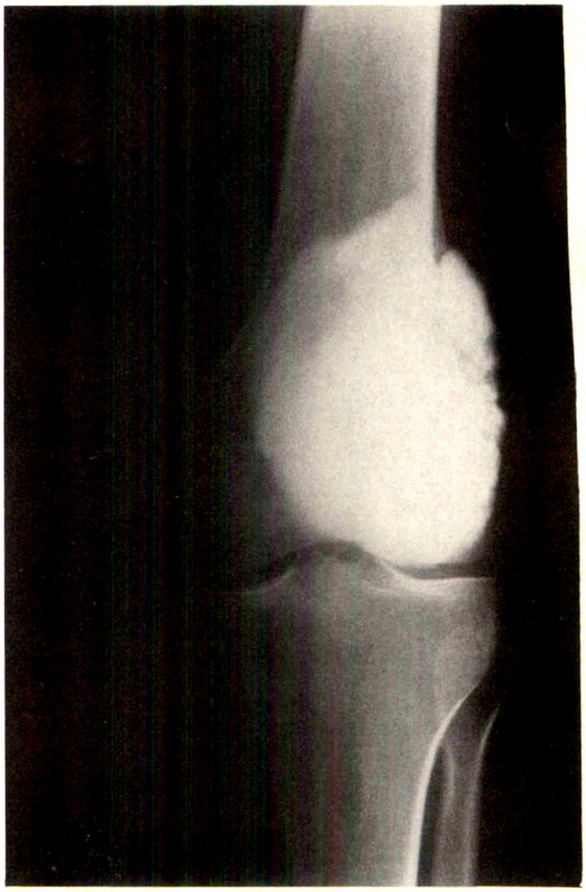

Figure 1. Osteosarcoma in distal left femur.

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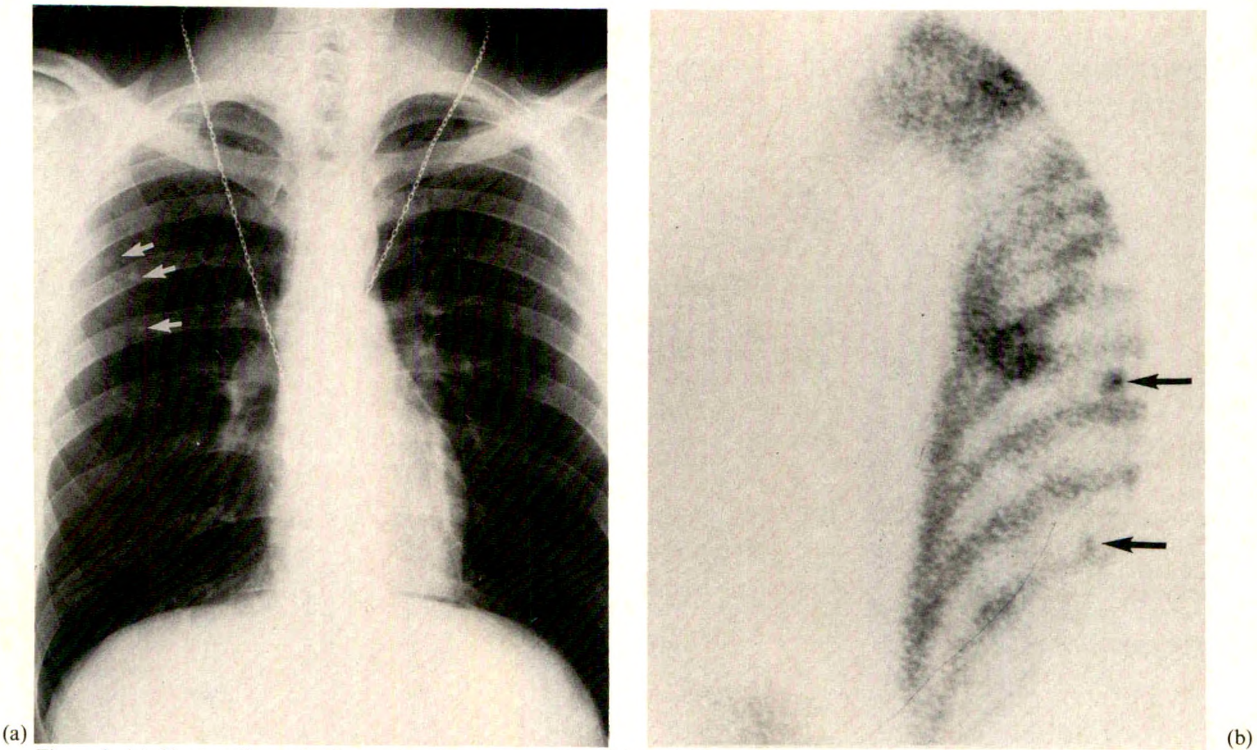


Figure 2. (a) Chest radiograph 10 months after presentation. Faint calcific nodules can be seen in the right upper zone (arrows). (b) Isotope bone scan performed at the same time showing abnormal uptake in the area of these nodules (arrows). The angle of the scapula mimics another lesion.

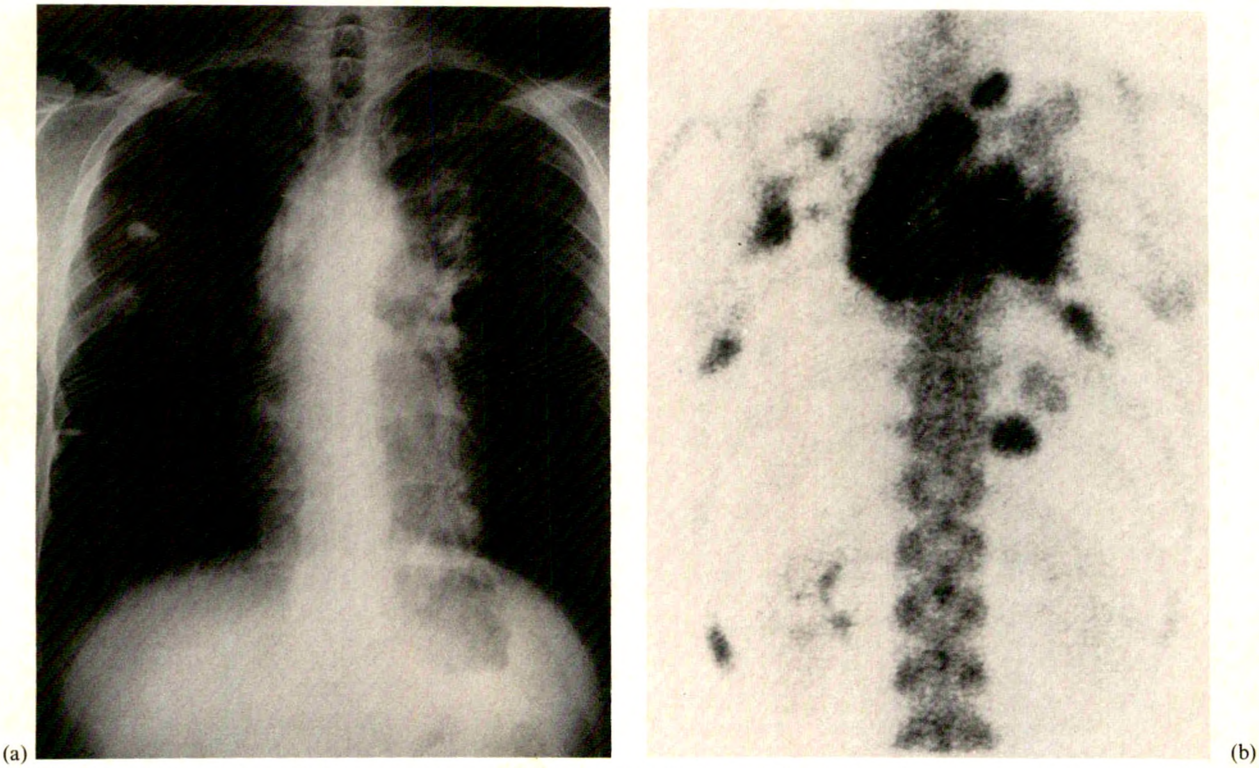
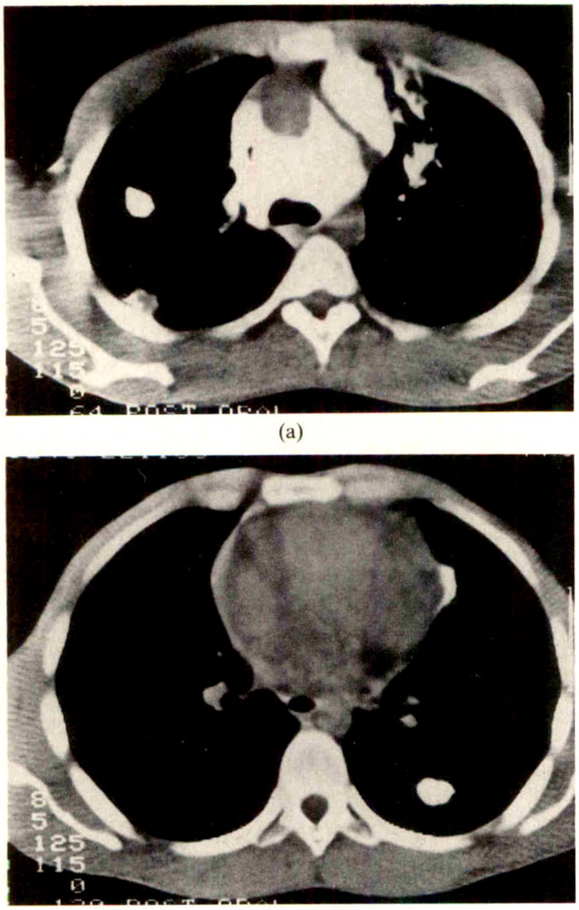


Figure 3. (a) Chest radiograph 18 months after presentation. Calcified nodules in the right lung have increased in size since the last film, and a large mediastinal and left hilar calcified mass is now present. (b) Isotope bone scan performed at the same time showing intense uptake in the mediastinum, lungs and ribs.



(a)

(b)

Figure 4. (a) Computerized tomography of the thorax showing calcific metastasis in the right lung, and a large calcific mass in the mediastinum extending into the left lung and left anterior chest wall. (b) Lower section demonstrates a calcific metastasis in the left side of the pericardium and a left lung metastasis.

uncommon. Van Zanten et al (1987) reported a case of a 16-year-old boy in whom calcific mediastinal metastatic disease was picked up on CT and subsequently demonstrated on bone scintigraphy. Two earlier reports demonstrated the value of CT in detecting calcific cardiac metastases (Dunnick et al, 1981; Pakter & Fishman, 1983). Phillips and Williamson (1987) reported pericardial metastases seen on a ^{99}Tc^{m}-MDP bone scan.

Our case is that of an extremely aggressive osteoblastic osteosarcoma reappearing 10 months after resection as osteoblastic metastases in the lungs, and subsequently in the mediastinum, pericardium and bones. The lung lesions were initially demonstrated on isotope bone scanning; at that time they could not be identified on CT.

This case demonstrates the greater sensitivity of bone scintigraphy than CT in picking up early osteoblastic metastases, although CT offers better anatomical localization of the lesions. Both are essential in the management of patients with osteosarcoma. In patients with osteosarcoma, a calcified nodule on a chest radiograph should not be presumed to represent an old granuloma, but should be correlated with scintigraphic activity while considering the possibility of metastatic disease.

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1990, *The British Journal of Radiology*, *63*, 981–982

Case of the month

An unusual cause of abdominal pain

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(Received October 1989 and in revised form February 1990)

A 57-year-old Asian woman presented with general malaise and intermittent pyrexia 3 months after a renal transplant. She was immunosuppressed with Cyclosporin A. Examination revealed low grade fever and tenderness in the upper abdomen; chest and abdominal radiographs were unremarkable. An ultrasound scan was performed, which showed a heterogeneous mass in the region of the head of the pancreas, displacing the superior mesenteric vein and compressing the inferior vena cava. There was no biliary dilatation. Computed tomographic (CT) scans of the abdomen were then obtained with intravenous contrast enhancement (Fig. 1), followed by endoscopic retrograde pancreatography (ERP) (Fig. 2). What are the abnormalities and what is the differential diagnosis?

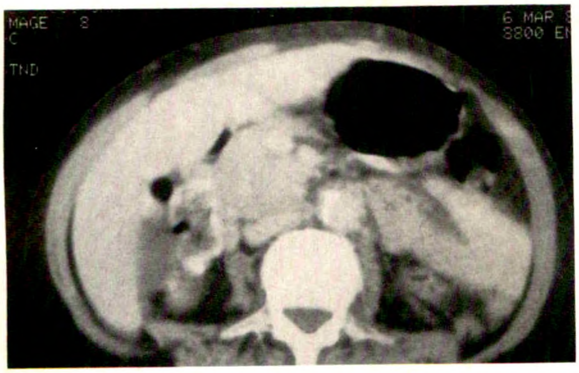

Figure 1. Computed tomographic scan of upper abdomen with intravenous contrast enhancement.

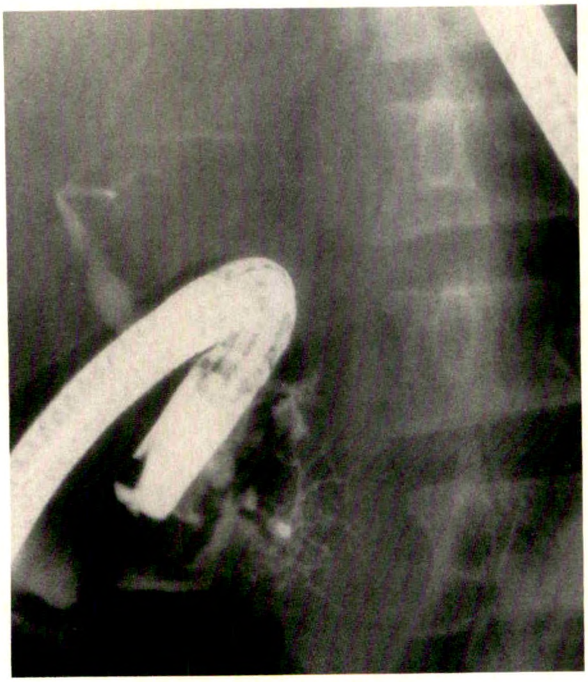

Figure 2. Endoscopic retrograde pancreatogram.

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Computed tomography confirms the presence of a heterogeneous, enhancing, hypodense mass in the head of the pancreas with displacement and compression of vessels as seen on ultrasound. On ERP the main pancreatic duct is occluded and the proximal side branches are disorganized with abnormal stenoses and beading. The main diagnoses are pancreatic carcinoma and chronic pancreatitis.

The patient underwent laparotomy where a hard mass was found in the pancreatic head causing obstruction to the duodenum. The mass was inseparable from the superior mesenteric vein and was thought to be an inoperable pancreatic carcinoma. A gastrojejunostomy and two Tru-cut biopsies were performed.

There was no evidence of neoplasm in the biopsy samples but caseating granulomata were present, and a Ziehl-Neelsen stain was positive. The patient received antituberculous therapy and a follow-up ultrasound scan showed no evidence of a residual mass. The patient remains well on follow-up 4 years later.

Discussion

Tuberculosis of the pancreas is rare even in countries where tuberculosis is endemic. Involvement of the pancreas can occur as part of a generalized infection such as miliary tuberculosis. Focal involvement is rarer still. Tuberculosis may present as acute or chronic pancreatitis (Stock et al, 1981) and as a mass mimicking carcinoma (Chandrasekhara et al, 1985). It has been postulated that infection of the pancreas may occur by two different mechanisms: haematogenous dissemination or by penetration of the organ by adjacent lymph nodes. This patient had no other evidence of tuberculosis, but she had been immunosuppressed and she was of Asian origin.

Tuberculosis is well recognized in transplanted patients in whom the presentation is atypical and diagnosis is difficult. Infection is predominantly pulmonary (McWhinney et al, 1981) and responds well to antituberculous therapy.

Involvement of the pancreas, as in this case, is unusual. A computerized literature search failed to reveal a similar case in the English literature in the last 15 years. The diagnosis of pancreatic tuberculosis is difficult. Clinical features may suggest the possibility, which should be investigated by CT and ERP; confirmation, however, must be histological.

Acknowledgment

I wish to thank Mr R. W. G. Johnson for permission to report this case.

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1990, The British Journal of Radiology, 63, 983

Correspondence

(The Editors do not hold themselves responsible for opinions expressed by correspondents)

High surface temperature of endovaginal probes

The Editor—Sir,

We have been concerned to hear reports of high surface temperatures on certain diagnostic ultrasound probes (Duck et al, 1989). It was not clear whether these temperatures resulted from faulty equipment or faulty design. Because of the sensitivity of vaginal tissue, we therefore undertook an evaluation of seven currently available systems to clarify these issues.

The criterion against which the systems were evaluated was the sub-clause 42.3 of BS 5724 Part 1 (1979): "Applied parts ofequipment not intended to supply heat to the patient should not have surface temperatures exceeding 41 degrees Centigrade".

One normally operating system was indeed found to exceed this level with the probe in air. The surface temperature, however, decreased when the probe was immersed in water at 37°C, but the temperature did not fall below 40°C when used in B mode, Doppler or Colour Flow modes.

Since water will remove heat by convection as well as by conduction, it is possible that the surface temperature of the probe when inside the vagina would be above the critical 41°C.

In mechanically oscillating probes, heat is produced throughout the probe as a result of inefficiency in the motor drive, and the probe may feel warm to the hand. In this particular case no motor drive was involved and the heat was generated in the transducer crystal as a result of the high power levels used. We recommend that endovaginal probes be operated at –3 dB on the transmitted power unless safe surface temperatures have been confirmed.

A fuller report and further information on the work of the Ultrasonic Equipment Evaluation Project (UEEP) can be obtained from the address below.

Yours, etc.,
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Reference

Duck, A. F., Starrit, H. C., ter Haar, G. R. & Lunt, M. J., 1989. Surface heating of diagnostic ultrasound transducers. *British Journal of Radiology, 62*, 1005–1013.

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Radiology 90 — Work in Progress

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Radiotherapy and Physics

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Limb function and quality of life of patients treated for lower limb soft tissue sarcoma

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Thirty-two patients (19 men, 13 women) have thus far been entered into a retrospective study of limb function and quality of life following the treatment of lower limb soft tissue sarcoma with surgery ± radiotherapy. A detailed assessment of range of movement using goniometry, manual muscle testing, assessment of gait, radiation fibrosis, lymphoedema and pain has been carried out in conjunction with a functional questionnaire, studying mobility, dressing, grooming, home environment, vocational and leisure activities. **Results.** The median age of patients at presentation was 44 years and the median number of months of surgery 51.1. Fourteen out of 32 patients had thigh tumours, seven lower leg, five buttock, three knee, three groin. Sixty percent had high-grade tumours and 26/32 received radiotherapy (mean dose 55 Gy). The range of movements was severely restricted in 13/26 patients receiving radiotherapy. Muscle power was severely or moderately impaired in 20/32 patients. Despite this, the overall functional score was normal in 50% and no patient had more than a mild functional disability. **Conclusion.** Despite moderate to severe reductions in range of movement and muscle power, most patients experienced minimal loss of functional ability.

Selective uterine arterial infusion of Cis-platinum for large carcinoma of the uterine cervix prior to radiotherapy

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A large carcinoma of the uterine cervix is often not amenable to radiotherapy, and this is one reason why the overall prognosis of the carcinoma is poor. Seven patients with a large (>5 cm) primary cervical carcinoma who had no previous therapy were selected to evaluate the efficacy of the uterine arterial infusion of Cis-platinum prior to radiotherapy. Six patients were at Stage IIIb and one at Stage IIb. Unilateral uterine artery was super-selectively catheterized in each course of infusion therapy by the Seldinger technique, and 120 mg/m^2 of Cis-platinum was infused in 2 hours be a mechanical pump. Four patients had one course of the infusion therapy and three had two courses. In six of the seven patients, more than 50% of the carcinoma was reduced 3 weeks after the infusion. Radiotherapy was completed in each patient after the infusion. Six patients are currently surviving at more than 2 years, and one is lost to follow-up; five are free of disease (one had para-aortic irradiation) and one had peritonitis carcinomatosa treated by chemotherapy. The current technique is useful to reduce the size of a large carcinoma of the uterine cervix and to obtain successful control.

Concomitant pelvic irradiation, 5-fluorouracil and Mitomycin C in the treatment of advanced cervical carcinoma

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This was a Phase I and Phase II study of 24 late (FIGO) Stage IIb and 39 Stage III patients. External beam radiotherapy was given daily, 5 days a week, using 15 x 15 cm parallel opposed pelvic fields. The first 20 patients had 45.00 Gy mid-plane dose in 20 fractions, Days 1–28, the last 43 patients had 50.40 Gy in 28 fractions, Days 1–43. This was followed by an intracavitary boost of 17.00 Gy to Point A in two fractions over 7 days. The first seven patients had concomitant 5FU 1g/m^2 /day (max 1.5 g/day) Days 2–5, 30–33 and 57–60, with Mitomycin C 10 mg/m^2 (max 15 mg) Days 2 and 57. Two patients had G4 cytopenia, and only two were able to have full-dose intensity. The 5FU dose was reduced to 0.8 g/m^2/day, for Days 2–5 and 30–33; Mitomycin C was given on Day 2 only. Treatment morbidity is now comparable to that of radiotherapy alone. Median follow-up was 16 months (range 6–44). Median survival was 35 months. The results have been compared to historical controls treated using the same radiation method alone. Two-year survival for late Stage IIb patients was 67% with the combination and 72% with radiotherapy alone; for Stage III, 67% and 49% respectively. Two-year pelvic control for late Stage IIb was 87% (combination) and 84% (radiotherapy alone) and for Stage III, 61% and 55% respectively. In contrast to reports from other centres, these results do not show an overall significant improvement on radiotherapy alone. A Phase III study may not be practicable.

The relationship between intrinsic cellular radiosensitivity and cellular levels of C-raf oncoprotein

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Although groups of tumours can be classified as either good, intermediate or poor responders to radiotherapy, there is considerable variation between patients in the radiosensitivity of tumours. At present there are no reliable methods of determining the intrinsic radiosensitivity of an individual tumour. An increased expression of the C-raf oncogene has been shown to be associated with decreased radiosensitivity in human fibroblasts, and antisense-mediated inhibition of this gene has increased the radio-sensitivity of human laryngeal tumour cells. We have therefore established the cellular levels of the C-raf oncoprotein using western blot analysis, in 15 human cultured cell lines of differing radiosensitivities. Our results indicate that there is a strong relationship between C-raf oncoprotein levels and the intrinsic cellular sensitivity to photon and neutron irradiations. Whether this relationship is coincidental or causative to the degree of radiosensitivity has yet to be determined. Our data suggest that cellular C-raf oncoprotein levels could form the basis of a predictive assay for the inherent radiosensitivity of human tumours.

Initial commissioning of a PC-based treatment planning system

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A Multidata treatment planning system, the RTP123, has recently been purchased by the Westminster Hospital. The basic system consists of a desk-top computer, digitizer and printer, but optional peripherals available include a water-phantom, densitometer, video camera and second work station. One of the advantages of the RTP123 over other similar systems is that the desk-top computer which stores the beam data used in treatment planning mode, also acts as the beam data acquisition control unit. Utilizing user-defined acquisition files, the water-phantom is controlled by the computer and the measured beam data is stored directly on floppy disc ready for transfer directly to the treatment planning program. The accuracy of the above system has been tested using a verification package developed by the American Association of Physicists. Three levels of tests are defined, representing increasing levels of complexity, to detect discrepancies between measured and computed doses. Results are presented for Level I and II tests and the problems encountered are discussed. Level III tests, which include such topics as complex field junctions, skin contour variations in off-centre planes and prominent internal inhomogeneities, are the subject of work in progress.

Use of simulation studies to determine the performance of a Constrained Least Squares Restoration technique in renogram deconvolution

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Deconvolution is an established tool in the analysis of nuclear medicine renograms. Standard techniques are based on exact solutions such as the matrix algorithm and FFT division which, because of the Poisson nature of the curves, tend to result in oscillatory or 'ill-conditioned' solutions. We have attempted to reduce the errors in the standard techniques by implementing an iterative Constrained Least Squares Restoration (CLSR) method in which the point of termination of the iteration occurs when a residual vector has a value less than an estimate of the noise power of the original renogram curve. This technique has been compared with two variations of the matrix algorithm and with FFT division. Four families of 15 simulated renograms were generated, each family having differing values of mean, minimum and maximum transit time and also having from 1% to 15% added noise. The 60 curves were subjected to the various deconvolution methods and the results compared. In each case the differences between the original and reconvolved renograms and between the original and generated response functions were smallest with the CLSR method. Additionally, a non-parametric ANOVA demonstrated that CLSR is the only technique which produces values of mean transit time which could not be considered to differ from the initial values. This work is now being extended to data from patients.

Development of an X-ray metrology laboratory

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The calibration of radiation-measuring instruments is necessitated by the Ionizing Radiations Regulations and draft guidance notes. It is also a requirement of any quality-related system and quality assurance, and is being applied increasingly to diagnostic radiology and mammography. Calibration of meters used in diagnostic radiology and mammography has never been considered seriously, and as the national standards have been directed at radiotherapy and radiological protection measurements, the calibration chain for diagnostic X-ray measurements is often inadequate. The UK breast screening programme has highlighted this. The present calibration methods and their deficiencies, and the development of a calibration facility specifically for diagnostic X-ray qualities, are described.

The value of multimodal imaging in wrist trauma

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Wrist trauma is a common orthopaedic problem but it may not be obvious clinically whether symptoms and signs arise from soft tissues or bones. Radiography at an early stage may be unhelpful and although a three-phase dynamic bone scan may show an abnormality in the carpus, accurate visual localization of this can be very difficult. For this situation, we undertook a study to see whether complimentary information could be provided by a system combining high resolution anatomical information from the hand/wrist radiograph with the functional images obtained in dynamic bone scanning. This multimodal imaging consists of three stages: geometric registration, data combination or fusion and display. Twenty-two patients with a history of wrist trauma were studied. Initially, bone scans with current hand/wrist radiographs were reported in the usual way by two independent observers, and then at a later date these cases were randomly reported with the combination display where the X-ray image is clearly visible through the colour coded radionuclide study. Both observers judged that in approximately half the cases more precise anatomical localization of an isotope abnormality was possible with the multimodal image available. This technique therefore could have implications in the clinical management of these patients and could be used similarly for tarsal lesions where again, accurate localization of an isotope abnormality is often difficult.

Test objects for rapid and advanced assessment of MR image quality

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Commercially available MRI test objects suffer from various deficiencies including lack of realistic tissue equivalent materials, little scope for multiple-slice or 3D measurements, excessive time required to perform protocols, extreme sensitivity to positional errors and, in some instances, limited scope for quantitation. We present an integrated test system which substantially overcomes these limitations. The test system comprises three basic objects for signal, geometry and relaxation plus a saline-filled annulus for simulating patient loading. All the standard MR image quality parameters may be measured in all slices simultaneously throughout an extended volume. Geometric measurements are self-correcting with respect to positioning errors. Additional advanced measurements include slice flatness, oblique slice angle, and 3rd-dimension MTF and slice ghosting in 3D FT scans. The filling material ($NiCl_2$) enables scans to be performed rapidly without signal saturation. Its relatively short T_2 enables the examination of fast imaging techniques and reduces phase noise errors. The relaxation times are essentially frequency independent, with reduced temperature dependence. The loading annulus closely matches the effect of the human head over the range 2–64 MHz. The test system will improve measurements of image quality using only three multiple slice scans, replacing very lengthy protocols.

Interventional Radiology and Ultrasound

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Blood viscosity changes induced by radiocontrast agents

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Blood viscosity has an important influence on blood rheology, which in turn is crucial to clinical angiography. We have therefore studied the differential effects of five different radiocontrast media on blood viscosity. The viscosity characteristics of erythrocyte-plasma suspensions were studied in the presence of various concentrations of each of the contrast media. Measurements were made over a range of applied shear rates in order to simulate laminar flow. Our results showed that with all the contrast media, as the concentration of the medium in the suspending phase was increased, the viscosity at low shear rates tended to fall, while the viscosity at high shear rates rose. However, we demonstrated that at both high and low shear rates, the rate of change of viscosity with contrast medium concentration differs markedly between the various media. Interestingly, the monoionic dimer Hexabrix was found to cause the least disturbance to the viscometric characteristics of whole blood. The non-ionic monomers had intermediate effects, whilst the conventional ionic agents caused most disturbance to blood viscosity. We suggest that the main properties of a contrast agent which are responsible for low viscometric disturbance are low osmolality and low density rather than ionic/non-ionic status.

Protein binding of iodinated contrast agents

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While it is generally agreed that binding to major plasma proteins of iodinated uro-angiographic X-ray contrast agents is weak, numerical estimates of the extent are controversial. At the pharmacologically relevant concentration of 1.2 mgI/ml some authors have reported plasma protein binding of between 1 and 6% of the contrast agent whereas, for the same class of contrast agents, others found no statistically significant binding. Since an association between protein binding and toxicity has been claimed, it was important to clarify the above discrepancies. Binding of contrast agent to human serum albumin (HSA) (5 ml, 4% w/v) and heparinized rabbit plasma (5 ml) was assessed by equilibrium dialysis at room temperature with 5 ml of 0.1 M phosphate buffer, pH 7.4, containing 0.15 M NaCl and contrast agents at concentrations of 0.12, 0.24, 1.2 and 2.4 mgI/ml. Quintuplet dialysis and control experiments were performed. Specific high-performance liquid chromatographic methods for the assay of iopamidol, iomeprol, iohexol, iopromide and ioxaglate in the equilibrium buffer were validated (relative standard deviation between 0.5 and 2% and an accuracy range from −3.38 to +0.67%). Binding to proteins was evaluated, measuring in duplicate the contrast agent concentration in the equilibrated dialysis buffer. None of the non-ionic contrast agents studied demonstrated measurable binding to HSA or rabbit plasma under conditions where binding with an equilibrium constant as low as 6.4 mM would have been detected. Thus it is concluded that none of the studied non-ionic contrast agents significantly bind to major plasma proteins. Previously reported correlations between protein binding and systemic toxicity are thus without foundation.

Laser angioplasty — enough to make your blood boil?

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Laser-assisted angioplasty is being performed in an increasing number of centres worldwide. The most frequently used device is one in which the laser beam is used to heat a metal probe tip to high temperature. The very purpose of such devices is, of course, to effect injury to the wall of the blood vessel in an abnormal and narrow or occluded area, but the obvious fact that such probes may also injure blood in the vessel appears to have been overlooked. There is the further consideration that any contrast agent in the blood in the area of the tip or (as is possible in some of these devices) injected through the probe while it is being heated, might also be damaged. Some *in vivo* experiments have been performed to study these effects. Contrast agents may be denatured with liberation of free iodide in solution and elemental iodine debris, which is available for embolization of the distal vessel. The blood supply boils and is denatured, with liberation of thromboplastins and exhibits accelerated clotting. Furthermore, untreated blood to which small amounts of this treated blood are added also exhibits accelerated clotting. The clinical implications of these observations are discussed.

Dynamic angioplasty: analysis of potential debris produced from atheroma and blood

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The Kensey catheter "KC" utilizes a fast rotating cam and fluid jet to recanalize arterial occlusions. We have successfully used 8F size in peripheral arteries; 5F is proposed for coronary use. However, there is some concern regarding the size of resulting particles. (1) Fresh endarterectomy specimens (n=84) were inserted in a flow circuit and randomized to undergo a simulated procedure using 5F or 8F KC at a range of predetermined cam speeds (CS), [20,000–80,000 R.P.M.] and flow rates [16–60 ml/min]. The collected particles were measured using Computerized Edge Detection Technique. (2) Samples of fresh blood (n=12) were exposed to 8F KC at same CS and FlR and filtered on 5–35 μm filters which were examined by scanning electron microscopy. Of the particles 9.2 (3.4%) were below 35 μm in diameter. In the remaining 9.2 (3.4%), significant differences were found between the maximum particle size (MPS) in each group. Increasing CS and FlR independently reduced the MPS from 985 to 170 μm ($p < 0.001$ and $p < 0.001$) in non-calcified atheroma. MPS was also smaller using 5F size ($p < 0.001$). MPS was larger in calcified lesions and was only significantly reduced by CS from 1260 to 381 μm ($p < 0.001$). No haematogenic debris was observed as a result of KC activation in blood. In conclusion, although most of the atheromatous debris collected was small, a low proportion of large particles was also detected. CS flow rates and catheter size had significant but unequal effects on the MPS. Unlike some lasers, no particles resulted from the use of KC in blood. These findings may be particularly important for the future application of KC in coronary angioplasty.

Initial experience with Rotacs: a new steerable disobliteration device

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Purpose. Crossing occlusions of the SFA prior to angioplasty can be difficult. Several devices have been developed to address this problem; none are currently amenable to steering and rely on the vessel wall to keep them within the lumen. We describe our experience with a slow rotating, non-abrasive disobliteration device (Rotacs) which allows the passage of a guidewire through a central channel and hence can be steered. Five patients with SFA occlusion over at least 6cm were selected. A standard approach was employed and a wire placed at the origin of the occlusion. The device was advanced through the lesion over the wire whilst being rotated. Routine angioplasty was performed after successful traversal. In three patients the outcome was successful. In two we failed to manoeuvre the Rotacs past a calcified plaque at the end of the occlusion. We describe a new disobliteration device which is unique since it can be steered over a wire. It is non-abrasive and pushes plaque and thrombus aside by virtue of tip wobble generated by slow rotation. Heavily calcified plaques remained an insuperable obstacle. The use of this device in selected patients promises to extend our ability to cross difficult occlusions.

Initial experience of crossing superficial femoral artery occlusions using the thermoprobe thermal angioplasty catheter

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Purpose. In a group of patients with occlusive (SFA) disease, we demonstrate a low-cost, easily portable alternative to laser powered "hot-tip" vascular channel production prior to angioplasty. Patients were selected because of anatomically difficult and/or long occlusions (four) or following failure of passage of a guidewire prior to angioplasty (two). A routine approach facilitated passage of the 7Fg round-tip plastic-coated device, which was advanced through the occlusion in 5 mm steps, each step performed over a 2 second period whilst heating the tip to 135°C. Routine balloon angioplasty followed in all cases after successful channel formation. Intravenous digital subtraction follow-up studies are available up to nine months post-procedure. **Results.** Five successful procedures were performed. There were no direct complications, such as vascular perforation, or any difficulty in passage of the catheter device. In one case a channel sufficient to allow subsequent angioplasty was not obtained. The long-term results appear to follow a similar pattern to those reported after laser assisted angioplasty. The radiofrequency-energized catheter allows "hot-tip" driven traversal of difficult and/or long SFA occlusions without the need for expensive laser equipment. This pilot study demonstrates the feasibility and efficacy of this technique.

The morphology of the anal sphincter complex following obstetric trauma — an analysis in 65 women

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Anal endosonography (AES) is a recently developed technique to image the anal sphincters and defects within these muscles. Faecal incontinence is a not uncommon complication of vaginal delivery, and 65 women presenting with faecal incontinence following obstetric trauma have been investigated by AES and anorectal physiology. At AES, using a Bruel and Kjaer 7 MHz rotating endoprobe, 57 (88%) patients were found to have an external sphincter defect, 41 (63%) internal sphincter damage, and 29/50 (58%) disruption of the perineal body. This triad of lesions represents a hitherto unreported complex characteristic of obstetric trauma. The physiology results are being compared to the AES findings. Although pudendal nerve and external sphincter damage in the puerperium have been found by physiology studies, the high incidence of internal sphincter damage was not appreciated prior to AES. A new radiological entity in obstetric injury is defined, namely, a combination of a right anterolateral external sphincter defect, rupture of the internal sphincter, and sometimes also of the perineal body. We are now examining primigravidae to try to establish which mode of delivery causes most damage to the anal sphincter complex.

Prediction of birthweight by fetal ultrasound biometry

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Ultrasound assessment of fetal weight provides an objective means of predicting birth weight at delivery. A total of 104 women with singleton pregnancies who were delivered between 37 and 42 weeks' gestation had ultrasound scans done during the fortnight before delivery. Biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL) measurements were obtained in all cases. Estimation of fetal weight (EFW) was done by four different methods using AC alone (Campbell), AC/BPD (Shepard), AC/FL (Hadlock) and AC/BPD/FL (Deter). Results were compared with values of actual birthweights at delivery. There was no significant difference between the mean birthweights of the 47 boy and 57 girl fetuses studied. EFW (Shepard) showed the least bias overall, mean percentage error 1.7%, standard deviation (SD) 10.6%. The other three methods significantly underestimated birthweights on average, EFW (Deter) mean −2.2%, SD 9.3% $p < 0.02$; EFW (Campbell), mean −5.4%, SD 9.5%, $p < 0.001$; EFW (Hadlock), mean −5.6%, SD 9.3%, $p < 0.001$. The percentage error in each group was significantly negatively correlated ($p < 0.001$) with the scan-delivery interval. For intervals up to 5 days, Deter and Shepard methods significantly overestimated the birthweight (mean 2.9%, SD 9.1%, $p < 0.05$, and mean 6.7%, SD 12.0%, $p < 0.001$ respectively) whereas the other two methods had negligible bias (Campbell, mean −0.3%, SD 9.3%; Hadlock, mean −0.6%, SD 8.4%). EFW (Shepard) was the most accurate in the 6–10 days' interval while the other methods significantly underestimated birthweight in this range. All four methods significantly underestimated birthweight at intervals of 11 days or more.

Intravascular ultrasound with 3-dimensional reconstruction: a new way of looking into arteries

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Angiography is inaccurate in estimating the degree of arterial stenosis and gives no information about the nature of obstruction. We have used a new ultrasound probe consisting of a 20 MHz transducer mounted within a 6 F catheter to investigate normal and atheromatous arteries *in vitro* (cadaver specimens) and *in vivo*. The device is inserted through a percutaneous sheath and provides real-time cross-sectional images from within the vessel lumen. Pathological correlation was obtained for the *in vitro* work. The cross-sectional area and shape of the lumen can be accurately measured. The intima, media and adventitia can be identified and the difference between the walls of elastic and muscular arteries shown. Thrombus can be differentiated from plaque. High-resolution images of plaque morphology can be obtained and we have tried to characterize plaque as calcified, fibrous, fatty or haemorrhagic. Preliminary results of ultrasonic-pathological correlation are shown. Changes in arterial wall following laser and balloon angioplasty were assessed. The cross-sectional images across a length of artery were reconstructed by computer to create unique 3-dimensional images of arterial wall. Preliminary results indicate that intravascular ultrasound shows considerable promise for quantifying luminal narrowing, characterizing plaque and aiding angioplasty.

Thyroid nodules — does ultrasound guidance improve cytological yield?

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There is accepted evidence to support the use of FNS cytology for the evaluation of thyroid nodules. Inadequate sampling results not only in repeated sampling but also in unnecessary surgery. We are prospectively comparing the results of FNA specimens obtained from the surgeon, and from a radiologist using ultrasound guidance. All new patients referred with a palpable solitary nodule, or dominant nodule in a multinodular goitre, are investigated by both operators, and randomization determines who performs the first aspiration. The cytologist is unaware of who has performed the aspiration. To date 55 patients have undergone both types of aspiration. Inadequate samples were obtained in five ultrasound and eight surgical patients. In 36 patients biopsies were comparable. To date a definitive histological diagnosis from a surgical specimen is available on six patients (three benign, three malignant). All were accurately diagnosed by ultrasound-guided FNA. Two of the three carcinomas were not diagnosed by surgical FNA. The early results of the study suggest that US-guided percutaneous aspiration may be more accurate than aspiration obtained by palpation only.

Diagnostic Radiology

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Radiological investigation of the ethmoid bone complex

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The importance of the ethmoid cell complex in the evolution of paranasal sinus disease has not been sufficiently appreciated in radiological practice. This is especially so in children, because of the complex anatomy of the ethmoid bone. By the age of 2 years the ethmoid cells have pneumatised the surrounding bones and have attained their adult size by 12–14 years. Unlike the other paranasal sinuses they do not increase in size with age. The radiological anatomy of the ethmoidal complex is discussed with particular reference to anatomical variations which may have a profound influence in the development and persistence of paranasal sinus infections. The information obtained by the newer imaging methods of CT and MRI have brought sharply into focus the limitations of conventional radiography in this field. The recognition on CT scan of congenital variations and abnormalities of the ethmoid bone is shown, and is of inestimable value prior to endoscopic nasal surgery. The advantages and limitations of CT and MRI in the diagnosis and spread of ethmoidal tumours are considered and illustrated and the relative merits of both methods discussed.

CT brain findings in lead encephalopathy in newborns and infants

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Lead oxide is the active constituent of a "local medicine" administered to newborns and infants in Oman, and frequently leads to severe encephalitis. Our studies on the brain changes of such cases showed the following. In the acute stages: moderate to severe generalized brain oedema, occasionally affecting the posterior fossa more than the supratentorial structures, leading to obstructive hydrocephalia. In the subacute stages: following the initiation of treatment with chelating agents, the oedema subsides quickly; occasionally "atrophic changes" are seen. In a few cases, very fine calcification appear in the caudate nuclei. These changes noted in 1–3 weeks of initial treatment. The residual changes: seen in follow-up scans (4 weeks to 3 months) show a variable degree of atrophic changes, and an increase in density of any calcification at the caudate nuclei. In few cases, the degree of the "brain atrophy" noticed in the scans performed in the subacute stages was reduced, with regression of the sizes of the ventricular system and the width of the cortical sulci. We think that severe changes in the subacute stages are due to something like temporary "dehydration" of the brain. We could find no relation between the severity of any of the above changes and the blood lead level.

Cervical ascultation combined with videoradiography in the assessment of pharyngeal swallow

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The sounds of pharyngeal swallow and adjacent breath sounds afford information which supplements videoradiography. Clinically significant patterns have been identified and the technique has contributed to the management of pharyngeally dysphagic patients. Fifty dysphagic patients have been studied. During the standard videoradiographic examination, a microphone attached to the patient's neck, over the larynx, records the sounds of pharyngeal swallow, as well as phonation, on the videotape audio channel. The sounds are monitored by the radiologist (with headphones) at the time of the examination. A number of swallow sequences have been subjected to computer-assisted acoustic analysis and display, to clarify abnormal patterns. In the sounds of pharyngeal swallow and the adjacent breath sounds, the initial and final discrete sounds, and the bolus transit sound are appreciated. These swallow sounds are reproducible in the individual patient: however, variation is apparent with alteration in the physical character of the bolus, and the quantity of air present. With bolus penetration into the larynx, the ensuing respirations are often followed by subtle clearing sounds, bubbling or even stridor. Overt coughing is readily apparent. Altered phonation may be appreciated. Videoradiography, with simultaneous cervical auscultation, identified the event of peristaltic pharyngeal swallow, important in the diagnosis of oropharyngeal spill, and the timing of laryngeal penetration of the bolus. An aperistaltic swallow is identified. Laryngeal penetration by the bolus has been identified by added sounds following the swallow, even when no radiographic abnormality was detected.

Compensatory mechanisms are likely to account for these added sounds. Cervical auscultation with videoradiography complements the "bedside" use of auscultation alone in the assessment of pharyngeal feeding impairment, by confirming suspected findings and acting as a baseline for further auscultation alone. Cervical auscultation during videoradiography enhances the diagnostic yield of the standard fluoroscopic procedure in dysphagic patients.

Measurement of renal cortical and medullary perfusion by dynamic computed tomography

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A method of quantifying tissue perfusion using dynamic computed tomography (CT) is described. A single-location dynamic CT sequence after an intravenous bolus of contrast medium is performed with time-density curves constructed from the tissue and aorta. By adapting to CT a method used in nuclear medicine to determine tissue blood flow the tissue perfusion can be determined from the ratio of the maximal slope of the tissue time–density curve and the peak height of the arterial time–density curve. Thirty-eight kidneys were studied, comprising 17 normal contralateral kidneys in patients with renal tumours, nine "normal" portions of kidneys containing renal tumours, four kidneys in patients with renal failure and eight in patients with hypertension (six during captopril treatment). The results in these groups are reported and the major sources of error discussed. The ability of dynamic CT to provide quantitative functional information in addition to good anatomical detail is not well recognized, and is potentially of value when the structures studied, such as the renal cortex and medulla, cannot be anatomically resolved by other functional imaging techniques.

Quantitative image analysis of vertebral body architecture — improved diagnosis in osteoporosis based on high-resolution CT

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The incidence of vertebral fractures cannot accurately be predicted by measurements of the trabecular bone-mineral content. Obviously the architecture of the vertebral body contributes to mechanical stability. The purpose of our study was to establish morphometric criteria for assessment of trabecular stability. The lumbar spines of 30 osteoporotic women, with and without vertebral fractures, were examined by midvertebral high-resolution CT scans, additionally to densitometric measurements of the trabecular bone-mineral content. Variations in the architecture of vertebral trabeculae were studied by quantitative image analysis in the vertical and horizontal planes. Assessment of trabecular width and intertrabecular spaces, as well as statistical analysis of 10 criteria by a computerized image analysis system (MIPRON, Fa. Kontron, Munchen), were performed. Women with vertebral fractures showed a different distribution of intertrabecular space diameters from that of patients without fractures. An index, which integrates densitometric and morphometric data of trabecular architecture should increase the accuracy of assessment of the risk of fractures in osteoporosis.

The value of repeated chest and abdominal X-rays in the follow-up of patients with testicular teratomas and seminomas

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Patients with teratomas and seminomas of the testis customarily have repeated follow-up chest X-rays and abdominal X-rays after lymphography, which can result in each patient having an enormous collection of films. This study assesses the contribution of chest and post-lymphography abdominal radiography in the detection of disease recurrence in 162 patients over a 9-year period. Eighteen (11.1%) patients developed recurrence; nine had teratomas and nine seminomas. Six patients developed recurrence in the thorax visible on the chest X-ray , which in four patients was the initial method of demonstrating the recurrence. However, five patients had raised serum markers at this time. Twelve patients (7.4%) developed recurrence in the retroperitoneal lymph nodes; of these, 11 had lymphography as part of their initial staging. In two patients relapse was demonstrated on the abdominal X-rays, but both cases had other evidence of recurrence. Two patients (1.2%) developed recurrence at other sites which were not detected on the chest or abdominal films. In conclusion, in only one patient was radiography the sole indication of recurrence and its use must be balanced against the high cost and the harmful effects of radiation.

Prospective anatomical and histological correlation of increased MR signal intensity in skeletal muscle adjacent to tumour

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Increased T_2 and short inversion recovery imaging (STIR) MR signal in muscle adjacent to malignant tumour may be due to tissue oedema or to infiltration of either malignant or inflammatory cells. We used spatially localized pathological sampling to investigate the aetiology of increased signal in muscle adjacent to malignant tumours. Five patients with extremity sarcomas were pre-operatively imaged at 1.5T with T_2-weighted spin-echo and STIR sequences to identify areas of increased signal in muscle adjacent to tumour. Post-operatively the intact, freshly resected specimens were re-imaged to obtain accurate anatomical localization for biopsies of muscles with pre-operative increased signal. The histological samples were blindly evaluated for cellular infiltration and for oedema. Of 63 samples from muscle with increased signal on pre-operative images, 24 (38%) were histologically normal, 14 (22%) were atrophic, 13 (31%) were oedematous muscle, nine (14%) had inflammatory cellular infiltration, three (5%) had malignant cellular infiltration. Differential characteristics— such as distance from tumour, distortion of muscle boundaries, disruption of fascial planes, T_2 relaxation time ratios to normal muscle, and T_2-weighted and STIR signal intensity ratios to normal muscle — did not significantly discriminate between oedema and inflammatory or malignant cellular infiltration. In conclusion, increased T_2-weighted and STIR signal in muscle adjacent to malignant tumour has many possible benign causes, but is rarely due to malignant cellular infiltration.

A new method for the small bowel enema examination

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The small bowel enema examination is a well-accepted technique for the examination of the small bowel. Currently the standard tubes used are the Nolan modification of the Bilbao–Dotter tube (Cook) and the Silk tube (Merck). We have been using a Levin type naso-duodenal feeding tube manufactured by Vygon for jejunal intubation. This is 125 cm long, of 14F diameter, and designed for single use. It is easy and quick to pass and allows a fast barium flow rate. It is also cheap, costing 74p. We are currently carrying out a prospective randomized trial comparing the Vygon and Nolan tubes. Intubation is carried out in the supine position. When the tube reaches the gastro-oesophageal junction the patient is turned into the right-side down semi-prone position and the tube advanced to the pylorus. The patient is turned semi-supine and the tube is advanced into the jejunum. Our early results are promising. Intubation time is always less than 15 min and the screening time for intubation is under 4 min. The total screening time for the examination is usually under 10 min and the examination is usually complete in under 30 min.

1990, *The British Journal of Radiology*, *63*, 993–994

The combined meeting of the Welsh and Northern branches of the British Institute of Radiology

Abstracts of papers presented at a BIR meeting held at Wrexham Medical Institute, Wrexham Technology Park, Croesnewydd Road, Wrexham on 9 June 1990

Chairman: Dr G. Griffiths

Non-invasive cardiac imaging, by G. M. Murray
Liquid crystal thermography in the investigation of suspected DVT, by J. R. Harding
The role of duplex ultrasound venography in the investigation of deep vein thrombosis, by D. J. Widdowson and C. H. Wright
Experience of transvaginal ultrasound in a district general hospital, by C. Wright and D. Jones
Cancer and the law, by D. Radstone
Magnetic resonance imaging in sports injuries, by G. H. Whitehouse

Non-invasive cardiac imaging

G. M. Murray
Wrexham Maelor Hospital, Clwyd, Wales

There are six modalities available to Wrexham radiologists for non-invasive cardiac imaging: plain radiography, ultrasound, nuclear medicine, computed tomography, digital subtraction angiography and magnetic resonance imaging. In practice, only the first three are employed. Having these services in the Department of Radiodiagnosis allows the most effective modalities for a particular patient to be employed, but the consequent workload on the Department increases every year.

Liquid crystal thermography in the investigation of suspected DVT

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St Woolos Hospital, Newport, Gwent, Wales

The use of thermography for the investigation of deep venous thrombosis (DVT) was first reported in the early 1970s. Since that time a wealth of data has clearly indicated that thermography has a very high sensitivity and is ideally suited to screening for suspected DVT. The technique, however, has not been widely used in the past because of the high cost of infrared scanning telethermography systems, their lack of portability and the need for a temperature-controlled environment. Liquid crystal thermography (LCT) solves these practical problems. Liquid crystal thermal detectors use state-of-the-art liquid crystal technology. The liquid crystals are microencapsulated for long life and stability and are deposited onto a highly flexible latex membrane. The membrane itself is supported in a unique flexible detector allowing superb conformability to even high curvature surfaces of the body. When brought into contact with the body, the liquid crystals change colour reproducibly with temperature to produce a full-colour thermal image. Each detector has a 4°C temperature span, and a range of detectors are available to investigate the clinical range from 20°C–30°C. A Polaroid photographic system instantly produces a recording of the thermogram for documentary purposes. The patient's identification, date and anatomical position can be recorded directly onto the image. Thermography is ideally suited to the screening of patients with clinically suspected DVT, patients at high risk of DVT and patients in whom venography is contra-indicated. The very high sensitivity of the test for both calf and thigh vein thrombosis has been well demonstrated previously. It has been suggested that the very small percentage of false negatives in some series is a result of thrombi which are not propagating or are undergoing fibrinolysis and which therefore have a low likelihood of embolization. Active thrombi which are potential emboli are positive thermographically. In the absence of a positive thermogram, the need for venography is obviated and anti-coagulation therapy can be withheld. Because LCT is non-specific, and, as all in conditions that can simulate DVT, cause increased temperature in the affected limb, further evaluation by venography or Doppler ultrasound is necessary when a positive thermogram is obtained. The pathological conditions which can raise skin temperature include ruptured Baker's cysts, superficial thrombophlebitis, erysipelas, inflammatory disease such as cellulitis and soft-tissue injury. With experience in simple pattern recognition, these thermal perturbations can often be recognized to reduce the false positive rate. The technique of imaging in LCT is rather different from other imaging modalities and has to be learned. The availability of a cheap, non-invasive technique could theoretically lead to an increased demand for investigation of suspected DVT, but this has not been my experience. On rare occasions (only once in nearly 200 requests), it can be impossible to perform LCT owing to large areas of infected varicose ulceration. In this study, 189 thermograms were performed on 182 patients (seven repeat examinations) over a 21-month period. There were 64 male patients with a mean age of 69 years and 118 female patients with a mean age of 64 years, the overall age range being 16–94 years. Initially, a small series of nine patients was investigated with venography performed irrespective of the LCT findings in order to gain experience and confidence in the technique. Subsequently, in 180 patients, LCT was performed as the first investigation, proceeding to venography only if LCT gave a positive or equivocal result, in 119 patients. The need for venography was avoided in 34% of patients overall, this figure increasing to 39% with more operator experience when only the last 90 patients are considered. Liquid crystal thermography avoids unnecessary irradiation (of particular value in younger patients and in pregnancy) and is totally non-invasive and free of risks of mortality or morbidity resulting from allergy to contrast media. LCT saves time, can be performed almost anywhere and is possible in some cases where venography is impossible. A negative thermogram excludes DVT avoiding the need for further investigation and this has considerable implications in terms of revenue consequences and/or radiologists' time. LCT costs approximately £3 for consumable materials compared with £40 for venography, *i.e.* a saving of £37 when venography is not needed, offset by an additional expenditure of £3 when both examinations are performed. If a third of potential venograms are not needed by virtue of negative thermography, *a saving of over £1000 per 100 patients is achieved.*

The role of duplex ultrasound venography in the investigation of deep vein thrombosis

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One hundred and sixty-eight duplex ultrasound venogram studies were undertaken over an 18-month period on patients with suspected deep venous thrombosis. Of these, 144 had a conventional contrast venogram performed. Following brief description of the technique of duplex venography, the results of the study are presented. The relative advantages and disadvantages of the two techniques are discussed. In conclusion, it is suggested that duplex venography could be the initial investigation of choice in the investigation of deep vein thrombosis.

Experience of transvaginal ultrasound in a district general hospital

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The value of transvaginal ultrasound in follicular monitoring has been detailed. A number of reports have indicated that the increased accuracy of transvaginal ultrasound in distinguishing normal from abnormal in early pregnancy and identifying ectopic gestation. We report our own experience in the Clwyd Hospitals over a 12-month period. The role of transvaginal ultrasound in identifying and distinguishing uterine and extra-uterine pathology is less clearly defined. The technique again appears to offer significantly better delineation of abnormalities in a variety of clinical circumstances. A number of examples are shown, and the role of Doppler Ultrasound and transrectal scanning are briefly discussed.

Cancer and the law

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The author is a practising radiotherapist and oncologist and former solicitor with an interest in the legal aspects of cancer management. The general legal principles involved in cancer cases are discussed and illustrated with some recent lawsuits.

Magnetic resonance imaging in sports injuries

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Magnetic resonance imaging (MRI) accurately delineates soft-tissue injuries, helping to define the appropriate management as well as being useful in evaluating the residual effects of past injuries. The ready application of surface coils, the lack of movement artefacts and good inherent soft-tissue contrast render MRI particularly appropriate in the evaluation of limbs. In addition, MRI has the advantage of being a non-invasive, rapid method which allows multiplanar imaging and achieves good spatial resolution. Not only is MRI more accurate than other imaging methods in evaluating soft-tissue injuries, but it has a high degree of reproducibility in sequential studies. Most of our experience is with injuries to professional footballers, most of whom can expect significant injuries on at least one occasion during a playing season. Examples given demonstrate the application of MRI in the evaluation of injuries to muscles, tendons, ligaments and intra-articular structures in footballers.

A report of this meeting is given in the BIR Bulletin at the back of this issue of *BJR*.

1990, *The British Journal of Radiology*, *63*, 995–1000

Book reviews

Emergency Interventional Radiology. Ed. by M. Pinson Neal, J. Tisnado and S.-R. Cho, pp. xviii+526, 1989 (Little, Brown, Boston), £53.50.
ISBN 0-316-59927-1

Interventional radiology has undergone great developments in the last 15 years or so and further advances continue to be made. Though many procedures are performed as elective, non-emergency cases, (*e.g.* angioplasty) many are performed as emergency procedures. This book concentrates on those procedures that are performed as emergencies or acute cases. The goal of the three editors (radiologists from the Medical College of Virginia) "is to provide a broad coverage of the problems, management, and appropriate interventional techniques in the traumatized/emergent pateint". The 23 chapters cover the complete range of interventional radiology and more, with contributions from 25 predominantly American interventional radiologists.

There are eight chapters on embolization for bleeding or following trauma. These include embolization in the abdomen, pelvis, extremities, post-operative and post-radiation situations and for oesophageal varices. These are on the whole good practical accounts and are well illustrated with cases. Two chapters on neuroembolization only just give a feel for these complex and risky cases. Such cases should only be tackled by specialists making these brief accounts of limited value. The account of bronchial embolization in haemoptysis is rather limited. It makes no mention of the occasional role of pulmonary angiography and embolization as well as dealing with the role of embolization in systemic non-bronchial arteries.

There is a good, balanced account of gastro-intestinal bleeding including the role of vasopressin therapy and embolization. I agree with the authors that the superior mesenteric artery should be examined before the inferior mesenteric artery, but disagree that bi-plane angiography is required to rule out aorto-enteric fistulae following aortic vascular surgery when most would not opt for CT. There is a very full account of the uncommon situation of acute mesenteric ischaemia.

The chapter on acute deep vein thrombosis and pulmonary embolism is one to avoid. Written by a surgeon, it concentrates on the surgical insertion of vena caval filters that have largely been superseded in Europe, if not in the United States. In addition, pulmonary embolectomy as well as catheter pulmonary embolectomy, a technique that has never gained any clinical acceptance, are covered in some detail. I am sure it is just a coincidence that both these devices bear the surgeon's name whilst none of the newer and more effective filters that can be easily placed percutaneously even gets a mention! (What is the point of editors?)

There is a good, but brief, account of thromboembolectomy with a much fuller account of fibrinolytic therapy for lower limb ischaemia. I do not think this account clarifies this difficult subject and it lacks clinical balance. There is no mention of a role for surgical embolectomy and the authors suggest that even chronic occlusions can be regularly and successfully lysed. Fibrinolitic therapy in both the visceral arteries and the upper limbs, I think, is a difficult subject and these chapters raise more issues than give clear guidance. Foreign body removal and the unknotting and repositioning of catheters form useful and practical chapters with very helpful diagrams, but acute coronary occlusion, decompression of acute colonic ileus and paediatric gastro-intestinal interventional radiology seemed to extend the brief of this subject unnecessarily. Chapters on abscess drainage, uroradiology, biliary radiational techniques complete the wide range of topics covered in this book.

Although this book is a bit like the curate's egg, most of its parts are good; I would on the whole recommend it. It is clearly laid out with plenty of good illustrations so that it would be a good source of reference for any radiologist confronted with a difficult emergency interventional problem as well as for use as a more general source of reference.

The real problems of emergency interventional radiology are highlighted in Chapter 1 (patient triage and facilities) which states "the emergency trauma/interventional radiologist must be readily available 24 hours a day 7 days a week . . . In addition . . . well trained nurses, radiologic technologists and others are required . . .". When this situation exists, together with "state of the art" angiography equipment, acute interventional radiology can begin to realize its enormous potential.

J. F. Reidy

Cardio-thoracic Imaging. Self Assessment in Radiology & Imaging, 7. By M. B. Rubens, pp. 208, 1989 (Wolfe Medical Publications, London), £24.00.
ISBN 0-7234-0906-4

This book is one of a series which share a common format of case presentations, illustrated by appropriate imaging, with questions and answers included in the text.

It covers a wide variety of cardio-thoracic conditions, with emphasis on the more common, but including some rare congenital cardiac abnormalities.

The range of difficulty of the cases is also diverse. In this way the author meets his aim of targeting the book at "anyone who looks at chest radiographs".

The overall format is excellent. Questions are given on one page with answers on the following. The radiographs are often duplicated with the answers which avoids repeated turning back of the pages. In about one third of the cases, additional imaging is illustrated. All modern imaging modalities are represented. On the whole, the image reproduction is good with useful labelling of features referred to in the text. In a few illustrations it is difficult to see the abnormality, even in retrospect.

I feel that it would have been useful, particularly to the non-radiologist, to cover the use of supplementary radiographic projections with their indications and also to mention the limitations of AP and supine films. Both can be the cause of confusion in everyday practice.

Although cases of congenital cardiac defects have been illustrated, commoner neonatal lung conditions such as RDS have not been included.

The book is easy to read and I would recommend it as a useful revision aid to FRCR candidates. The question-and-answer format provides an alternative approach to the more formal text. Priced at £24, the book is good value for money and would be an appropriate acquisition for teaching hospital department libraries.

S. E. Evans

British Medical Bulletin, Vol. 45, Number 4. Non-invasive Cardiac Imaging. Ed. by D. G. Gibson, pp. ii + 830–1119, 1989 (Churchill Livingstone, Edinburgh), £25.00.
ISBN 0–443–04200–4

As the editor of this "state of the art" review points out, in the last 20 years there has been little change in invasive cardiology (angiography) but there have been considerable developments in non-invasive techniques so that now with the exception of coronary artery anatomy virtually every cardiac diagnosis can be made non-invasively.

This small volume aims to give an introduction and general account of these non-invasive cardiac imaging techniques to "anyone newly entering the field, either as a clinician or research worker".

The contents are equally divided between echo-cardiography, nuclear medicine and magnetic resonance with a chapter on ultrafast CT scanning. Well known cardiologist, radiologists and physicists, mainly from the UK but also from the United States and Holland, have produced chapters on their specific areas of interest. The constraints obviously imposed on the authors by a book of this size has meant that the style of the text is concise with good and balanced reviews of the effectiveness of each technique, even if detailed accounts are not possible.

There are excellent but brief accounts of the technical aspects of nuclear medicine and echo-cardiography that will be useful to a general reader without burdening him with physics. The account of the physics of MR is I think too long (there are plenty of good accounts elsewhere for those who want to wrestle with the physics) especially when no general practical points about MR imaging are included. The remaining chapters cover nuclear medicine techniques for left ventricular function assessment, myocardial perfusion imaging, clinical MR imaging, echo-cardiography in valve disease and cross-sectional echo-cardiography in congenital heart disease. There are further chapters on the assessment of left ventricular function by echo-cardiography and a good general account of colour flow mapping. These all give the reader a good feel for the value of these techniques as well as their limitations.

I am sorry that the chest radiograph does not merit a mention, despite its limited value in coronary artery disease and its diminishing value in congenital heart disease as paediatric cardiology has become more neonatally orientated. It certainly has more clinical effectiveness than either MR used for flow measurement or MR studies in atheroma, the chapters on which will not convince the general reader that they have much practical value at present. Generally, this review is a well balanced but not too detailed account of the "state of the art" in non-invasive cardiac imaging. I agree with the editor in his introduction that this book is an excellent starting point for any clinician, physicist or radiologist who is interested in the subject. I think the radiologists early in their training or even later would find this review well worth reading.

J. F. REIDY

Manual of Diagnostic Imaging: A Clinician's Guide to Clinical Problem Solving, Second edn. Ed. by W. H. Straub, pp. xxi + 373, 1989 (Little, Brown and Company, Boston), £9.95.
ISBN 0–316–81888–7

The choice of the most suitable radiological investigation, or sequence of investigations, to solve a particular clinical problem is often complex, particularly as more imaging modalities become available and as there is increasing emphasis on the efficient and effective use of radiology in clinical practice.

In the second edition of this manual, Professor Straub and his colleagues in the University of Pittsburgh School of Medicine have brought together valuable referenced information and have recommended diagnostic pathways for some 75 commonly encountered clinical problems in which radiological investigations may be helpful.

There is an excellent introductory chapter on the clinical selection of imaging studies, which emphasizes cost-benefit considerations in the US context; also the use of the radiologist as a consultant. The final chapter provides an update on newer imaging technologies including MR imaging and spectroscopy, positron emission tomography, single photon emission computed tomography as well as picture archiving and communications systems.

The text naturally reflects American concerns and assumes a greater access to sophisticated imaging modalities than is generally available in the UK. Despite this, the handbook will be most useful to practising clinicians as well as those in training, as a guide to what radiology can offer with regard to clinical problem solving.

H. BADDELEY

Chesney's Radiographic Imaging. Fifth edn. Ed. by J. Ball and T. Price, pp. xii + 380, 1989 (Blackwell Scientific Publications Oxford), £17.50.
ISBN 0–632–01943–3

Producing a book which does justice to the reputation of the Chesney's sufficiently to be called a revision, yet has a style which gives credit to the new authors is, as the preface to the book indicates "no easy task". However, this original aim has been achieved as the book provides the reader with a foundation in radiographic photography in a manner which student radiographers will find easy to relate to.

The first 30 pages introduce the reader to image characteristics and the production of the image, whilst from Chapter 4 onwards the authors concentrate more on the principles of radiographic photography under sections relating to the radiograph, the fluoroscopic image, special imaging techniques, perception and interpretation of images.

Changes in technology demand that student radiographers are given a firm gounding in the materials and processes in current use. They may then comprehend and adapt to any new concepts which have to be incorporated into their daily professional activities.

Chesney's Radiographic Imaging provides the foundation required and is indexed to ensure easy referencing. Additional manufacturers' literature may be required to ensure up-to-date information in some areas, but otherwise a book which could be readily recommended for student radiographers.

DAWN FORMAN

Handbooks in Radiology: Skeletal Radiology. A Year Book Handbook. By B. J. Manaster, Ed. by D. G. Bragg and A. G. Osborn, pp. xiv + 449, 1989. (Year Book Medical Publishers, Chicago), £19.00.
ISBN 0–8151–5754–1

Skeletal Radiology is one of a series of nine pocket-size text books in radiology. The book is divided into six major chapters covering tumours, arthritidies, trauma, metabolic bone diseases, congenital anomalies and miscellaneous diseases including haematological disorders and infection. All of the information is presented in outline form as a series of numbered facts, and in several chapters the same format is repeated in the description of different diseases. This layout is intended to allow easy reference with repeated use. "Key concepts" are summarized at the beginning of each section to enable review of the most pertinent information. The subjects addressed are covered in considerable detail, despite the small size of the book. There are no radiographic reproductions and lesions are depicted in the form of line drawings. In the case of fractures, such illustrations are effective but they are not so successful in conveying the appearances of bone tumours. When a suspected bone tumour is being considered, visualization of radiographs demonstrating similar features forms such an essential part of the evaluation, that I feel *Skeletal Radiology* could not easily be used alone as a "reference for troubling musculoskeletal cases" as suggested in the editors' introduction.

The information is up to date and throughout the book there is helpful discussion concerning the appropriate use of current imaging techniques including CT scanning and MRI.

The preface states that the book is designed primarily for use by radiologists in training and that orthopaedic surgeons and rheumatologists may also find it useful during training. The editors' introduction expands the potential readership and says, "it is intended as an introduction for the medical student and beginning radiologist". The outline format of the book inevitably means that some basic knowledge of film interpretation and disease processes is assumed, which is not appropriate in the case of these two groups. In addition, the emphasis on detailed factual information would be unnecessary in an introductory text.

Skeletal Radiology will probably be of most use as a reference book for the practising radiologist with a special interest in musculoskeletal radiology and possibly for the trainee preparing for exams. In deciding which easily transportable books to buy and carry with them, both groups should take account of the fact that there are other pocket-size radiological texts written in outline form which cover all of the organ sub-specialities but provide less detailed information on the musculoskeletal system.

CHRISTINE W. HERON

Catalog of Prenatally Diagnosed Conditions. By David D. Weaver, pp. xxvi+251, 1989 (The John Hopkins University Press, Baltimore, USA), £29.00.
ISBN 0-8018-3771-5

This small book, *Catalog of Prenatally Diagnosed Conditions*, by an eminent American clinical geneticist David D. Weaver, aims to encompass our current knowledge as gleaned from the literature of the methods of diagnosis of 448 disorders which have been detected during pregnancy; in this it succeeds.

The information is divided into three sections: the text, the references and the index. Each chapter in the text represents a disease category and the larger chapters, such as congenital malformations, are sub-divided. As might be expected, this particular chapter includes almost half of the total number of prenatally diagnosed conditions. Other chapters cover dermatologic and haematologic disorders, fetal infections and inborn errors of metabolism. A chapter on chromosomal abnormalities has been included but aims only to describe those in which non-cytogenetic findings have been described, for example the cystic hygromas so characteristic of Turner's syndrome. Each condition may be readily found within the relevant chapter by its alphabetical listing, usually using the most accepted nomenclature, although there are one or two exceptions, such as the Martin-Bell syndrome rather than the more commonly used fragile X syndrome. Alternative names, acronyms or abbreviations are also included. Each condition has been assigned a reference number and, of particular benefit to clinical geneticists, the five digit "McKusick number" is also indicated. There is a brief synopsis of rarer conditions and the methods used to diagnose the disorder or to detect abnormalities associated with the disorder are listed under each heading. These include ultrasound, with some Doppler studies, echocardiography, radiography, amniography, fetoscopy, amniocentesis, biochemical and histological studies, chorionic villus sampling and DNA analysis. The abnormality detected with each method, and the appropriate references are listed. Superscripts are used to indicate gestational age at diagnosis and other recurring findings. For instance, one superscript denotes that the diagnosis is presumed correct because the condition has occurred in a previous sibling or parent, or the embryo has been exposed to a specific and recognized teratogen. In other words, there has been a clearly defined predisposing factor.

The second section comprising the references is laid out in alphabetical order by first authors, as referred to in the main text. Over 1200 references have been included, taken from 103 English speaking journals. The references are up to date and comprehensive.

The index, the final section, is excellent, including the named conditions and alternative names. Specific prenatal findings are included, such as "cysts", "decreased fetal movements", "hydramnios", etc. and the conditions associated with these findings are presented under each heading with the relevant catalogue number to refer back to the main text. This provides a comprehensive cross reference system for various findings and enables a differential diagnosis to be reached.

This book, the only one in its field, is of great relevance to all diagnosticians, including imagers, histopathologists and biochemists, working in the field of prenatal diagnosis and management. It will also prove particularly valuable to clinical genetecists and paediatricians concerned with counselling for recurrence of a particular disorder. Not only should this *Catalog of Prenatally Diagnosed Conditions* be available for reference in all libraries, but I would recommend that those actively involved in caring for the unborn child should have a copy readily to hand.

My one reservation, as mentioned also by the author in his concluding remarks in the introduction, is that prenatal diagnosis is a relatively new and therefore rapidly expanding branch of medicine covering many disciplines. Inevitably, this work will require expansion as our findings and knowledge of the subject increase. I look forward to further editions of this valuable contribution to medicine.

CHRISTINE M. HALL

Radiologic Correlations with Anatomy and Pathology. The Mediastinum. Second edn. By E. R. Heitzman, pp. xiv+358, 1988 (Springer Verlag, Berlin), DM248.00.
ISBN 3-540-18727-8 (Berlin)
0-387-18727-8 (New York)

This is the second edition of *The Mediastinum*, the first having appeared over 10 years ago in 1977, and, for those familiar with the book, it closely resembles the first edition with identical chapter headings and format. The contention of the author — that accurate radiological diagnosis is based on a thorough understanding of correlated radiographic anatomy and pathology — also remains the same and the book is a brilliant exposé of this philosophy.

There are 10 chapters in all mostly concerned with separate regions of the mediastinum. Illustrations are profuse and high quality: anatomic specimens mostly in cross section with plain radiographs, conventional and computed tomograms, and angiograms, but no MRI. There is a liberal text that gives about equal weight to anatomy and pathology together with about 850 references.

When this book first appeared in 1977 I, along with many other radiologists, found it extremely exciting. Here was a key to the mediastinal treasure chest allowing one to identify and use the wealth of mediastinal structure revealed by the recently introduced high kV radiographs. I approached this second edition with high expectations and have been rather disappointed. My disappointment stems mainly from the fact that the book has changed relatively little over a decade during which there has been an outpouring of information concerning the mediastinum based largely on CT, which, at the time of the first edition, was in its infancy. The total number of pages remains essentially unchanged at 350. About 600 imaging illustrations in the first edition have increased by 140 and, although quite a number of these are CT images, CT only forms just over a quarter of the imaging illustrations. Many of the CT illustrations remain from the first edition and are suboptimal by current standards, though it must be admitted they usually make their point. Each chapter has only a handful of new paragraphs and the text remains largely unchanged with the exception of an excellent section (including illustrations) on the hilar regions and a discussion of the American Thoracic Society classification of mediastinal lymph nodes.

The Mediastinum is an essential volume in any radiological library and anyone who takes a particular interest in chest radiology should own one. I am less clear what to recommend to those who already have the original version and on balance I feel that they might do best to hold on to their first edition and spend limited book funds elsewhere.

A. G. Wilson

Clinical Radiobiology. Second Edition. By A. H. W. Nias, pp. viii + 279, 1989 (Churchill Livingstone, Edinburgh), £29.50.
ISBN 0-443-03340-4

In her review of the first edition of this book, Dr Spittle commented on the absence of sections on cytotoxic chemotherapy and on statistics, but said it should be a standard text for Part I of the FRCR examination. In what is now a single author book, Professor Nias has expanded the text on chemotherapy but, correctly in my view, not included a chapter on statistics. The other comments by Dr Spittle are, in general, as valid for this edition as for the first. This is essentially an introductory textbook covering those aspects of radiation biology which are of most importance to the trainee radiotherapist. I stress the word "introductory" because, whilst I believe every clinician taking the Part I exam should know what is in this book, I would certainly expect them to have a much more detailed knowledge of, for instance, the mechanisms of action of cytotoxic drugs, and of fractionation and the linear-quadratic formalism, than is provided here.

What is distressing to this reviewer is the large number of errors, some typographical but others not. I find it curious that the author describes the action of misonidazole as biophysical but that of halogenated pyrimidines as biochemical (p.52). On p.61, in the second equation, D_2 is described as the final slope which, of course, it is not. The linear-quadratic equation is incorrectly written on pages 62 and 197. Many would disagree with the statement on p.197 that curves with a low α/β ratio are slowly bending. There are other examples one could quote.

Nevertheless, the objective as outlined in the preface to the first edition, "to provide for the clinician who wishes to have some understanding of the basic biological principles of radiotherapy" is well satisfied by this second edition. But FRCR examinees should be expected to know more!

N. J. McNally

Radiology of the Esophagus. By Marc S. Levine, pp. xiv + 373, 1989 (W. B. Saunders, Philadelphia), £64.00.
ISBN 0-7216-2906-7

In these days of the increasing use of endoscopy, the role of barium examinations for the diagnosis of oesophageal disease may seem open to question. Other than the one gulp and two spot films for the exclusion of a stricture or pouch, the technique would seem consigned to the archives of radiological practice. Levine and Laufer give the lie to this. This book is a superb example of how a good test, well practised and interpreted, need not be overtaken by more modern or glamorous alternatives.

The 373 pages comprising 16 chapters are all well written and are illustrated with over 600 radiographs of the highest quality. The book deals with the oesophagus from examination technique and anatomy in Chapter one, through benign and malignant tumours in Chapters 9 and 10, to end with the paediatric oesophagus in Chapter 16.

Each topic is covered in a systematic fashion with the standardized format of clinical features, pathogenesis endoscopy and then radiology. The numerous radiographs associated with each topic, *i.e.* eight on Barrett's oesophagus, are well annotated and placed close to the topic under discussion, rather than being found several pages away, as so often seems to be the case.

The chapters on benign oesophageal tumours and infectious oesophagitis are two of the best in the book, and show how a well performed barium examination may be both an adjunct to endoscopy or on occasion surpass it. There is a useful appendix of differential diagnoses, and all topics are well referenced.

If there is one complaint, and it is a small one, it concerns the topic of vascular rings. I feel this merited more attention, and in a book as well written as this, the opportunity to dispel some of the mystery surrounding this topic has been missed.

The high cost of £64.00, although not excessive, precludes purchase by all but the most enthusiastic of individuals. It is however, a book that should be readily available to all practising in the barium suite, and should encourage us to attempt to produce double contrast studies of the highest diagnostic quality.

Levine has produced a textbook which is both aesthetically pleasing and a delight to read.

J. A. Gleeson

Combination Therapy in Urological Malignancy. Ed. by P. H. Smith, pp. xiii + 278, 1989 (Springer-Verlag, Berlin), £68.50.
ISBN 3-540-19528-9 (Berlin)
0-387-19528-9 (New York)

What is new in the treatment of the urological cancer? Chemotherapy for bladder cancer, biological response modifiers for renal cell cancer, complete androgen blockade in prostate cancer, new approaches in reconstructive surgery and radiotherapy. These are all promising avenues of clinical research, but their place in the routine treatment of patients and their integration with standard management policies remains to be defined.

This book sets out to explore the "state of the art" of combined modality treatments in urological cancer. Contributions come from eminent specialists representing a total of 10 countries. Topics include developments in surgical reconstruction, radiotherapy, chemotherapy and immunotherapy, as well as site related contributions covering bladder, prostate, renal, penile and testicular cancers. The achievements of clinical trials in urological malignancies are well and comprehensively reviewed by Drs Raghavan and Tannock, and there are interesting contributions on quality of life assessment and a section on medical audit and the cost implications of different treatment policies, including screening for urological cancer. The book succeeds in providing well written, up-to-date reviews on the treatment of urological cancer. However, most of the available data relates to single modality therapy supporting the premise that surgery, radiotherapy or chemotherapy alone is often inadequate to control urological tumours. "The recognition of this fact justifies the increasingly determined search for effective cytotoxic drugs which must eventually play a primary role in the management of all tumours" states the preface. Perhaps so, but, apart from in testicular cancer, the activity of the currently available chemotherapeutic or systemic agents does not give rise to immediate optimism, and the emphasis given to the importance of clinical trials in testing combined modality therapies is important and timely. Urological surgeons, radiotherapists, and clinical and medical oncologists with a particular interest in urological cancer will find this a useful update and an enjoyable read. The lifespan of the book, however, will be relatively short as important new information will become available over the next 2 years or so from the current randomized trials of combined modality treatments.

D. P. Dearnaley

Pediatric Bone Imaging—A Practical Approach. Ed. by S. Mahboubi, pp. xiii + 215, 1989 (Little, Brown and Company, Boston), £55.00.
ISBN 0-316-54381-0

This book approaches the difficult problem of putting into perspective the different modalities which can be used to image the skeletal system in children. This is a multi-author text bringing together the expertise of 11 distinguished authors from the United States. The chapters can be divided into two basic types: one group demonstrating the uses of the different imaging modalities in musculo skeletal disorders in children, *e.g.* ultrasound, angiography, computed tomography (CT), magnetic resonance imaging (MRI) and scintigraphy; the remaining chapters reviewing the uses of all the modalities in particular clinical circumstances, *e.g.* evaluation of joint disease, primary soft-tissue lesions, primary bone lesions. There is a separate chapter by an orthopaedic surgeon on the clinical view of imaging.

Inevitably, there is some overlap caused by the multi-author format and this is aggrevated by the different styles of chapter. In spite of these criticisms, this is a good review of imaging in paediatric bone disease, with the MRI contributions being particularly valuable. This book can be recommended to all involved in paediatric bone imaging who want an up-to-date review of the relative merits of the differing techniques available.

D. W. Pilling

Intraoperative Ultrasonography in Hepato-Biliary and Pancreatic Surgery. (A Practical Guide.) Ed. by G. Gozzetti, A. Mazziotti, L. Bolondi and L. Barbara, pp. x + 183, 1989 (Kluwer Academic Publishers Group, The Netherlands), £60.00.
ISBN 0-7923-0261-3

The increasing importance of intra-operative ultrasound is now recognized by surgeons and radiologists alike. The considerable superiority of this technique in detecting small tumours in the liver and pancreas, over the combination of pre-operative ultrasound and operative palpation, is now fact. This book, by European authors, is written as a practical guide for those becoming acquainted with this. It is said to be directed at those both well versed in ultrasound and also surgeons wishing to learn.

The initial chapters deal with basic ultrasound physics and ultrasound terminology. This is followed by the main text, which covers the role of intra-operative ultrasound and its accepted areas of limited hepatic resection, endocrine pancreatic surgery, and, finally, liver transplantation and portal hypertension where, with the addition of Doppler, patency vascular anastomoses can be confirmed prior to abdominal closure.

In each chapter there is a detailed basic description of the long-standing, well recognized ultrasound appearances of the main pathologies, and also a series of directions as to how to drive an ultrasound probe. Consequently, much of the text, although well written, is totally superfluous to the experienced ultrasound radiologist. The strength of the book lies in its scientific approach to the subject, any statement being justified by the results of high quality studies and supplemented by an extensive set of references. It contains numerous illustrations, including colour plates, which must have contributed to its high cost, and which will certainly increase its appeal to a wider audience.

To my knowledge, it is primarily the radiologists in this country, who work in conjunction with the surgeons, who are developing and carrying out this service. This book, because of its laborious approach to basic ultrasound, will be of limited value to this experienced group of operators. As for the surgeons, it is more difficult to judge whether this book will be of major interest. Certainly, it will be a subject that both established and trainee surgeons will need to be aware of, but not necessarily practising. For this reason, it may be a useful addition to a large library, but not to an individual collection.

J. Karani

Pros and Cons in PTA and Auxiliary Methods. Ed. by E. Zeitler and W. Seyferth, pp. xxi + 289, 1989 (Springer-Verlag, Berlin), DM128.
ISBN 3-540-19306-5 (Berlin)
0-387-19306-5 (New York)

Although PTA is now a well established treatment, its applications are still expanding and its techniques improving. Just when radiologists were beginning to look at angioplasty more critically, especially with regard to indications, results and complications, a whole new array of trans-catheter techniques for treating occlusive vascular disease has emerged. Amidst the welter of enthusiasm that new devices invariably attract, the same mistakes are being made as in the evaluation of PTA in the early days.

The title of this book offers hope and the prospect of critical evaluation but I am afraid it is misleading. First, PTA does not feature, but this book instead focuses exclusively on the new "auxiliary methods". The editors have assembled nearly 100 authors, mainly radiologists with Germans and Americans predominating, who have produced 11 chapters on laser assisted angioplasty, eight on endovascular stents, five on new mechanical devices and with small sections on thrombolysis, percutaneous thrombo-embolectomy and drug therapies. The 11 chapters on laser angioplasty include accounts of experimental work as well as much on the technical details and specifications of different laser technologies. A small series of laser angioplasty using bare laser fibres is described, which seems now to be of very limited relevance. Detail is missing in most of these accounts with only short-term follow-ups. Invariably, the number of stenoses as well as the length of occlusions are not given, and there is no attempt to compare conventional PTA with laser PTA.

Throughout this book, many well known protagonists give encouraging accounts of their particular new technique, which is usually based on no good evidence. Sadly, the "cons side" gets very little space, and so this part of the book is very weak. The stent chapters are a particularly good example of this, where the arguments against stents are given one page only. The surgeon writing this brief criticism goes on to state that stents are good after iliac PTA, but that femoro-femoral bypasses give better results. The use of Nitinol stents is detailed in 79 patients, with no details of the technique and with no account of the type of lesions treated. Results are described as "good". This methodology allows no useful assessment of their value.

The "total" cons in the whole of this book merits only 12 pages. A major problem in PTA, but especially in PTCA, is the problem of re-stenosis. Cardiologists have looked at this in great detail, along with the patient and technical factors that might increase or decrease its incidence. Radiologists have not had anything like the same experience of re-stenosis, and it is a pity that some space was not found for this important subject, which in many ways is the "raison d'etre" for the new auxiliary devices.

There are brief but useful chapters on vasospasm and its treatment, but I do not feel that the difficult subjects of intra-arterial thrombolysis and percutaneous thromboembolectomy were given enough space to do them justice. I believe that a surgical viewpoint is of great importance in looking at the treatment of occlusive disease, but not by stating that the disadvantages of thrombolysis included "the psychological stress of being buried under tons of electronic equipment and frightened out of his or her senses by continuously having various tubes shoved in and out of his or her body". This statement is only matched by one of the lofty objectives given by the editors in their preface, of vaporizing atheromatous plaque so that it can then be exhaled through the lung as a gas!

In conclusion, I believe that the pros are not put across convincingly enough to make out a case for these new techniques, and the cons are hardly given a reasonable chance. I am sure, though, that the cons of this book far outweigh the pros. I do not think anyone wanting to look seriously at the new techniques and to the future would gain much from reading this book. In this rapidly changing field, I think more critical accounts have been already written and will be published in journals and reviews. I would not recommend it to anyone, except somebody who had a little knowledge of the field, and who wanted to get an idea of the range of new techniques emerging and the lack of science associated with their early use.

J. F. Reidy

MRI/CT and Pathology in Head and Neck Tumours. Ed. by Roland Chisin, pp. xiii + 170, 1989 (Kluwer Academic Publishers, The Netherlands), £66.50.
ISBN 0-7923-0227-3

Magnetic resonance imaging (MRI) and computed tomography (CT) have an increasing role in the diagnosis of head and neck tumours, and this monograph presents 35 cases in which CT and MRI have played a role in diagnosis and staging. Although two orbital cases are included, the emphasis is on tumours of the paranasal sinuses, temporal bone, salivary glands, pharynx and larynx. Glomus tumours are included but acoustic neuromas and haemangiomas are not.

The clinical, radiological, surgical and pathological findings of each case, with selected comments, are accompanied by well captioned radiological images of good quality. Black and white photomicrographs provide the visual pathological correlation in most cases, whilst the commentary attempts to link the MRI and the specific histological findings.

The layout is profligate with many underfilled pages for such a slender volume; however, it does allow the reader to adopt a quiz approach, which is quite compelling.

The book is not designed as a reference text, and the bibliography is limited. However there is a useful final chapter on MRI strategy in evaluating head and neck tumours. The use of gadolinium DTPA is discussed and illustrated, but short tan inversion recovery sequences (STIR) and MR-guided biopsy are not mentioned.

The price for such a slim volume is quite high; however, the book does provide an educational resource in this specialized but expanding area of imaging.

H. Baddeley

Handbook of Breast Imaging. By M. E. Peters, D. R. Voegeli and K. A. Scanlan, pp. x + 344, 1989 (Churchill Livingstone, New York), £49.50.
ISBN 0-443-08620-6

The title of this book is a misnomer in that, while the bulk of it is devoted to mammography, ultrasound is compressed into one brief chapter and there is no mention of the adjunctive, albeit minor, roles of computed tomography and magnetic resonance imaging. There are introductory chapters on the anatomy and pathology of the breast, and on the clinical diagnosis of breast masses. The latter, by a surgeon, surprisingly still describes the use of frozen sections. A chapter on the physics of mammography deals with the subject in a practical and comprehensive manner. However, the description of grids could have been expanded, particularly in regard to the trade off between contrast improvement and patient dose. The risks of mammography have not been expounded elsewhere in the book, and it would have been appropriate to develop this topic in the chapter on physics. The radiographic aspects of mammography and the radiological evaluation of the mammogram are described in subsequent chapters. The main section of the book deals with mammographic abnormalities. A sound, common sense approach is shown throughout this section, which is well illustrated in terms of both quality and quantity. Despite basing the description of mammographic findings on a pathological classification, there is a strong emphasis on the radiological differential diagnosis. There are useful chapters on mammography following surgery and irradiation to the breast, the male breast and galactography. A chapter on the pre-operative localization of non-palpable breast lesions is detailed, although no mention is made of stereotactic fine needle aspiration.

In summary, this book is recommended as a clear and concise review of mammography, suitable not only for trainees but also for radiologists who are starting mammography.

G. H. Whitehouse

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BIR Bulletin

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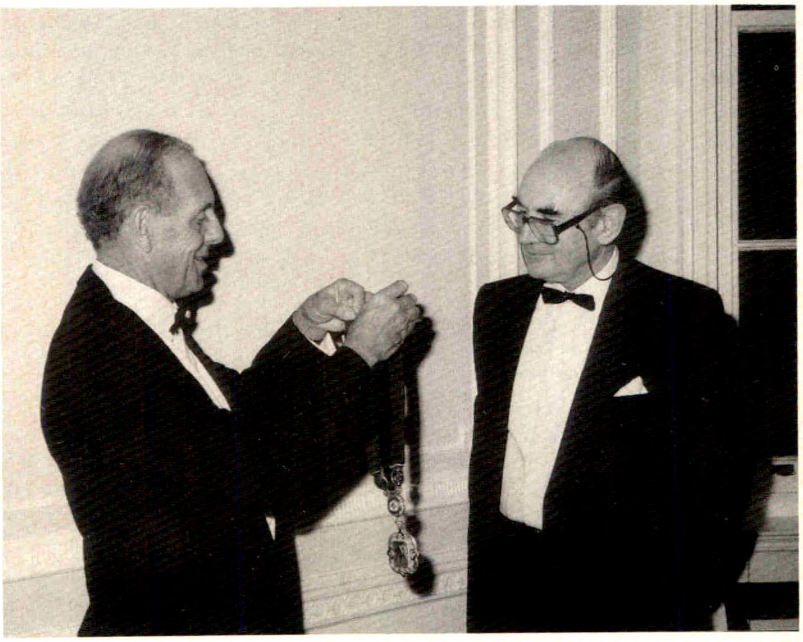
36 Portland Place, London W1N 4AT
The British Institute of Radiology is not responsible for opinions expressed in the BIR Bulletin

Professor C. A. F. Joslin

The New BIR President

Charles Joslin began his professional career as a development engineer for EMI in 1950 following National Service. It may perhaps be unique that two succeeding Presidents of the Institute started their professional lives as development engineers, even if they took diverging paths following their professional beginnings. In 1952 Charles Joslin became interested in the field of clinical measurements and so began a dual career of medical studies as a student, and electronics as a Consultant engineer. During pre-clinical training he lived a schizophrenic existence which involved studying such diverse matters as the life cycle of the amoeba during the day at the Northern Polytechnic in London and in the same Institute teaching Electronics and Mathematics during the evenings.

This double life continued even after qualifying in medicine when he worked as a houseman and also served both on the Council of the British Institute of Radio Engineers and as a founder member of the Biological Engineering Society. However, the field of clinical measurements failed to offer a promising career structure, status or realistic salary; a situation which still causes considerable problems for scientists in medicine.



Last year's BIR President, Professor Kit Hill, ceremoniously passing the medal over to Professor Joslin at the President's dinner in September

It was perhaps a natural process to become interested in radiotherapy, especially as it then offered a more satisfactory career structure. In 1961 he started a radiotherapy career and his electronic engineering interests began to recede but did not finally cease until about 1970. He trained in radiotherapy at Charing Cross Hospital and the Royal Post Graduate Hospital Hammersmith, during which time he developed various research interests including hyperthermia. However, this never developed beyond some experimental studies when, following a visit to the United States where he met Ulricht Henschke, he become interested in brachytherapy afterloading. At this time his heads of department at

Charing Cross Hospital, Dr Peter Kunkler followed by Dr Daniel O'Connell, were exploring the clinical possibilities of using remote controlled, high activity afterloading techniques for treating gynaecological cancers.

This was far more interesting to Charles Joslin than hyperthermia and, working under Daniel O'Connor together with physicists Norman Ramsey and Bill Liversage at Charing Cross Hospital, he become involved in the development of the "Cathetron" machine in conjunction with TEM who manufactured six machines as a pilot project.

At that time there was virtually no clinical experience in the use of high activity sources for treating gynaecological cancer. It was a question of getting on with the clinical applications and waiting for radiobiology to advise why it should or should not work. Having taken part in some experimental laboratory work and various clinical applications, he moved to Velindre Hospital, Cardiff, as a Consultant Radiotherapist, joining his previous chief Peter Kunkler.

At Velindre Hospital, he was fortunate enough to find another Cathetron. There he took charge of the clinical development of the machine and rapidly moved from treating patients on a pre-operative basis to treating on a radical basis. Other applications which originally began at Charing Cross Hospital were also developed, including the afterloading of "treatment moulds" for treating skin cancers. These were exciting times in Radiotherapy with such developments as high energy linear accelerators, treatment simulators, hyperbaric oxygen and the "Ellis" mathematical model for radiotherapy. His major interest remained with the clinical development of high activity afterloading which resulted in him becoming known for this interest internationally.

Within two years of arriving in Cardiff Peter Kunkler left to take up the first Chair in Radiotherapy at Leeds University. Following Peter Kunkler's retirement, Charles was appointed to the Chair in 1974 some ten years after being Peter's Junior Registrar. It was, of course, purely coincidental that Leeds also had a Cathetron machine but other challenges were now facing him and in particular he hoped to develop the Yorkshire Regional Cancer Organization. He chaired the Advisory Committee for six years during which time he played a major role in the development of the organization. As Medical Director of the Cancer Registry he made this one of the supporting structures of the Cancer Organization. He also held the opinion, which he still holds today, that if we could only detect cancers at one or two stage levels earlier a greater impact in cure rates would occur than for any major treatment advance. He became involved in a research group evaluating and developing various blood tests for the early detection of cancer. While he moved away from this approach some years later he then became involved with breast cancer screening.

As part of a National breast cancer early detection research programme, Professor Joslin and a surgical colleague, Graham Harris, were responsible for a research study into the value of a breast self examination (BSE) which formed part of the National study. Although BSE finally lost out to mammography, the place of BSE for detecting early breast cancer was shown. Charles joined the Forrest Committee responsible for the Forrest report on Breast Cancer Screening and is particularly gratified that, of the many committees he has served on, the results of the recommendations of this one are clearly being applied.

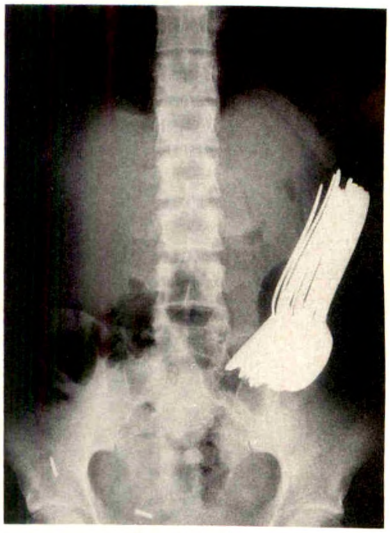
If Charles Joslin could be considered a collector it would be of membership of committees and Chairman of a number of these. However, he does not encourage invitations to join committees and particularly loathes self-perpetuating committees, but is well satisfied if the outcome is of practical value and application.

A Spoonful of Sugar....or Several

A Case Report by Nicola H. Strickland, MA (Oxon), BM, BCh, MRCP

Department of Radiology,
Hammersmith Hospital,
Du Cane Road,
London W12 ONN

While "spoon feeding" may represent an important milestone in every normal child's development, even Freud would probably have agreed that to impact in transit between the oral and anal stages may have serious consequences, not least for the family silver!



Bon appetit

Report of the Summer Meeting of the Welsh Branch of the British Institute of Radiology

June 8–9, Wrexham, North Wales

The Summer Meeting of the Welsh Branch of the British Institute of Radiology took place on Friday and Saturday 8th and 9th June, 1990, in conjunction with the Northern Branch of the BIR.

The meeting was attended by the current President of the BIR, Professor C. R. Hill. The dinner took place in the Bryn Hywel Hotel, Llangollen and the Scientific Meeting in the New Wrexham Medical Institute adjacent to the Maelor General Hospital, Wrexham.

The Scientific Meeting was chaired by the local host representative Dr Malcolm Greensmith in the absence of the Chairman of the Welsh Branch, Dr Glas Griffiths, who was indisposed through illness. A short Business Meeting opened the session before progressing to the Scientific Papers.

The first speaker of the morning was Dr G. M. Murray of Wrexham Maelor Hospital who talked on non-invasive cardiac imaging. He gave an overview of the imaging modalities available for investigating the cardiovascular system before concentrating on ultrasound and nuclear medicine. He put forward the view that radiologists should interpret echocardiographic studies and was keen to point out the value that still derived from plain radiographs. The scope of echocardiography was described with numerous examples of diagnosis made by echocardiographic investigation. Reference to colour flow Doppler diagnoses was also made. In nuclear medicine blood pool agents and thallium scanning were discussed and this led on to discussion of the imaging of myocardial infarction and myocardial perfusion. The value of pyrophosphate imaging in patients with chest pain, equivocal ECG and enzymes was demonstrated, as was the use of thallium studies for the perfusion of the myocardium. The paper indicated clearly to the audience the scope of cardiac imaging taking place in Wrexham.

The second paper was a guest appearance by Dr J. R. Harding from Gwent, who gave a very entertaining and polished account of his experiences with Liquid Crystal Thermography in the investigation of suspected DVT. This included practical demonstration of the liquid crystal equipment. Though thermography has tended to fall into a degree of disrepute with radiologists, Dr Harding stimulated considerable interest by his description of an application of liquid crystal thermographic equipment to a clinical situation which causes most radiologists considerable work. He described the technical aspects of liquid crystal equipment and moved on to consideration of its clinical value and cost saving. He stressed very much the non-invasive aspects and lack of mortality and morbidity. He pointed out that the use of LCT has decreased the need for venography in 34% of patients who might otherwise have undergone this invasive investigative modality. He suggested that a saving of more than £1000 per 100 patients was possible.

There then followed two joint presentations, the first on the role of duplex ultrasound venography in the investigation of deep venous thrombosis was by Dr D. Widdowson and Dr Carl Wright. They described their experience of 168 duplex ultrasound venographic studies over a period of 18 months. The paper included a brief description of the technique with its advantages and disadvantages relative to conventional venography. It was felt that the principal advantage was that the technique was non-invasive and was particularly useful in cases of contra-indication to contrast medium. They suggested that in their experience false positive results were rare, though false negative results were rather more common. They suggested that as a result of their work duplex venography should be the initial investigation of choice in the investigation of patients with suspected deep vein thrombosis.

The pre-coffee session was a second joint presentation by Dr Carl Wright and Dr Douglas Jones on the application of the technique of trans-vaginal ultrasound in a district general hospital. The talk opened with discussion of the value of trans-vaginal ultrasound scanning in folicular monitoring as well as recent reports that trans-vaginal ultrasound was useful in distinguishing normal from abnormal pregnancy and was of additional value in the identification of ectopic gestation. Experience of ultrasonographers in Clwyd hospitals over a 12-month period was presented, including their experience with the identification of ectopic pregnancies and other pelvic pathology.

Following coffee there was contribution from the Northern Branch in the person of Professor G. H. Whitehouse from the Department of Diagnostic Radiology at the University of Liverpool. He talked about the use of magnetic resonance imaging (MRI) in sports injuries. Magnetic resonance imaging will accurately delineate soft tissue injuries and had greatly influenced the instigation of appropriate management as well as having considerable impact on the assessment of the residual effects of past injury. The investigation of limbs was of particular interest and the advantages of MRI from the point of view of its non-invasive qualities and good spatial resolution in multiple planes was stressed. MRI had been found to be more accurate than other imaging methods in the evaluation of soft tissue injury. Professor Whitehouse described experience in Liverpool with professional footballers and numerous examples were given of injuries to muscle, tendon and articular structures. He stressed the benefits of MRI in assessing such injuries including the accurate delineation leading to more appropriate management, its non-invasive nature, its reproducibility and thereby its value in follow-up of injuries. It was clear from the paper that the management of injury in athletes has been greatly advanced by the application of this imaging modality.

The last scientific paper, another contribution from the Northern Branch, was by Dr David Radstone, a Consultant Radiotherapist at Western Park Hospital, Sheffield. He gave an entertaining, and at times disturbing, view of cancer and the law and at times applied himself to the role of the new radiological investigation in such medico-legal situations. He indicated that there was a steady rise in the number of cases proceeding to court action most often involving chemotherapy rather than radiotherapy. Improved management and patient survival had led to the patient surviving long enough to experience side effects from the treatment. This was usually neurological or dermatological and he gave several illustrative cases. He stressed the importance of informed consent.

The Scientific Meeting completed, there was opportunity for informal discussion both scientific and social over lunch. This was an end to a very well organized and enjoyable meeting of the Welsh Branch.

Dr N. Powell
Secretary
Welsh Branch of the BIR

The proceedings of this meeting can be found on pages 993–994.

BIR Calendar

Unless otherwise indicated, enquiries about the following events should be addressed to the Conference Manager, British Institute of Radiology, 36 Portland Place, London W1N 4AT (Tel. 071-580 4085).

Practical Issues in Breast Cancer Screening
January 17, 1991
Scientific Societies Lecture Theatre
Joint BIR/RCR/RSM all day meeting
Organizer: Prof. G. H. Whitehouse
Speakers: Drs J. Law, N. M. Perry, G. J. Bickler, A. R. M. Wislon, C. Rubin, M. J. Michell, F. E. White, J. Austoker, A. K. Tucker and Prof. J. Chamberlain

Cerebral Blood Flow Practical Measurement and Clinical Relevance — a Multimodality Approach
February 12, 1991
All day Meeting
Organizer: Dr A. H. Smith
Chairmen: Dr D. A. Cunningham, Prof. B. S. Worthington and Dr R. A. Shields
Speakers: Prof. J. D. Pickard, Prof. M. A. Smith, Dr S. Padayachee, Prof. M. Levene, Miss D. Dorrance, Dr P. Butler, Dr J. N. H. Brunt, Dr K. E. Britton, Prof. P. J. Ell, Dr D. J. Wyper, Mr A. R. Naylor, Dr A. Lammertsma and Dr I. R. Moseley

CT — Are the Bells and Whistles Worthwhile?
February 20, 1991
All day meeting
Organizers: Drs A. Dixon and S. Golding
Speakers include: Dr J. Dobbs, Dr J. E. Adams, Dr J. Gillespie and Mr A. D. Sant

Radiobiology Proffered Papers
February 22, 1991
Organizer: Dr R. Camplejohn

Radiation Oncology/IPSM
April 10, 1991
All day meeting organized by IPSM

RADIOLOGY AND ONCOLOGY 91 and MED X RAY
29 April–1 May
Metropole Hotel, Brighton

Radiation Oncology and Radiobiology: Particle Therapy
June 7, 1991
Organizer: Dr R. D. Errington

The New Legislation — Friend or Foe (After the White Paper ... and into Europe)
June 13, 1991
All day meeting orginized by the Industry Committee
Chairmen: Prof. C. A. Joslin, Dr O. Craig and Miss D. Rigg
Speakers include Dr J. Roylance, Dr I. Watt, Mr E. Sutherland, Prof. I. Isherwood and Mr P. Richardson

Conversazione
June 27, 1991
Painter's Hall, London
Lecture: " Half an Eye on the Sky", by Sir Stephen Furness.

Notice to all prospective delegates at Radiology & Oncology 91

Please note that there was an error on the Advance Programme circulated with the October BJR.

The date for the **Annual Dinner** on the Congress booking form should have read **Monday 29 April** and the date for the **Civic Reception, Tuesday 30 April**. Members wishing to reserve tickets for either of these events are asked to amend their booking forms accordingly. Page 8 of the leaflet gives the correct dates.

The BIR Conference Office apologizes for this mistake.

Library News

The BIR Library is open weekdays 9 a.m.–5 p.m. (7 p.m. on Tuesdays and Thursdays).

The journal stock includes more than 100 titles. Although journals may not be taken out of the library, there is a photocopy service, also available by post or Fax. A list of current journals is available on request and is also published in the March and September issues of the Bulletin. Most books (except the historical collection) are available on loan.

Members can apply to the BIR librarian for a visitor's card which allows limited use of the RSM library for reference purposes, including photocopying and searches.

Recent additions to the library

ANDREW, E. R., 1990. Clinical Magnetic Resonance: Imaging and Spectroscopy.

BERKOVITZ, B. K. B. & MOXHAM, B. J., 1989. A Colour Atlas of the Skull.

BEYER, D. & MÖDDER, U., 1988. Diagnostic Imaging of the Acute Abdomen. A Clinico-radiologic Approach.

DONDELINGER, R. F. et al (Eds), 1990. Interventional Radiology.

FAIRCHILD, R. G., BOND, V. P. & WOODHEAD, A. D. (Eds), 1989. Clinical Aspects of Neutron Capture Therapy.

MACCUAIG, N. & HOLT, R. (Eds), 1988. Tomography and Scatter Imaging: Applications in NDT. Proceedings.

NCRP, 1988. Comparative Carcinogenity of Ionizing Radiation and Chemicals. NCRP Report 96.

NCRP, 1989. Guidance on Radiation Received in Space Activities. NCRP Report 98.

NCRP, 1989. Exposure of the US Population from Diagnostic Medical Radiation. NCRP Report 100.

NCRP, 1989. Exposure of the US Population from Occupational Radiation. NCRP Report 101.

SUTTON, D., 1988. Radiology and Imaging for Medical Students, 5th edn.

WEBB, S., 1990. From the Watching of Shadows. The Origins of Radiological Tomography.

WILDE, P., 1989. Doppler Echocardiography. An Illustrated Clinical Guide.

New Periodical

Activity. Selectron Brachytherapy Journal

New BIR Members

Medical

Mr Andrew Bulman, MS, FRCS, FRCR
(Leeds) Radiotherapist/Oncologist
Dr Terry S. Creasy, MA, MB, BChir, FRCSEd, FRCR
(Oxford) Diagnostic Radiologist
Dr Alison A. Duncan, MB, ChB, MRCP, FRCR Part I
(Birmingham) Diagnostic Radiologist
Dr Robert J. Etherington, MB, ChB, FRCR
(Cheshire) Diagnostic Radiologist
Dr Zia S. Faruqui, MB, BS
(Manchester) Diagnostic Radiologist
Dr Christine M. Hall, MB, BS, DMRD, FRCR
(London) Diagnostic Radiologist
Dr David G. Hughes, MB, BS, MRCP, FRCR
(Manchester) Neuroradiologist
Dr Williamina Kincaid, MB, ChB, FRCR
(Glasgow) Diagnostic Radiologist
Dr David H. Melcher, MA, MB, ChB, FRCPath, FIAC
(Brighton) Pathologist
Dr Bernard Menanteau, Professor of Radiology
(France) Diagnostic Radiologist
Dr Kenneth A. Miles, MB, BS, FRCR
(Cambridge) Diagnostic Radiologist
Dr Sundareswaran Ramakrisnan, MB, BS, MD, MPhil, DMRT, FRCR
(Sheffield) Radiotherapist/Oncologist
Dr Michael Reilly, MB, BCh, BAO, FRCR
(Manchester) Diagnostic Radiologist
Dr David E. Roberts, MB, BCh
(Liverpool) Diagnostic Radiologist
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(Cheshire) Diagnostic Radiologist
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Dr Elisabeth A. Tilley, MRCP, FRCR
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(London) Radiographer
Mr Bruce Selkirk, BSc
(Cheshire) Product Technologist
Mrs Susanna J. Stevens, DCR (Diagnostic)
(Lincolnshire) Radiographer
Dr Robin J. Wilks, BSc, PhD, MIPSM
(Exeter) Physicist

Industry News

Sonicaid S8000DM Distance Fetal Monitoring System

With this new CTG data transfer system it is possible to Monitor the Mother at home or at a local antenatal clinic and transmit the complete CTG record the the hospital for objective analysis and archiving. This removes the need for repeated, stressful trips to the hospital for monitoring.

The fetal heart rate, contractions and fetal movements are stored in a small hand-held computer. The labelled data is then transmitted by telephone to the hospital using sophisticated error checking algorithms. Transmission, display and analysis of a thirty minute trace takes less than two minutes.

For further information contact Christine Price, Oxford Sonicaid Ltd, Quarry Lane, Chichester, West Sussex PO19 2LP. Tel: 0243 775022

Ultrasound Research Project in Edinburgh

A £500 000 research project, funded jointly by the Department of Trade and Industry, SERC and Dynamic Imaging Ltd, will probe new techniques in colour flow mapping and velocity profiling thus linking the research effort to clinically useful applications. Principal participants are Professor Norman McDicken and Dr James Dripps at the University of Edinburgh, and Dr David Evans at the University of Leicester and members of Dynamic Imaging's R & D team.

D. S. Cairns, the Managing Director of Dynamic Imaging said, "We are delighted the DTI has recognized that we have in this country a growing ultrasound industry and research base and that it is worthwhile to encourage this industrial and academic activity in the most direct way possible — that is by providing substantial funding assistance.

The object of the research is not to produce products but to devise technology building blocks which can then be exploited by Dynamic Imaging in product development. It is expected that a number of scientific papers describing aspects of the work will be published in due course.

For further information contact Linda Robichaud on 0508 415282.

Philips Supply to Nottingham City Hospital

Philips Medical Systems have won the prestigious order to supply the Radiotherapy equipment for the new Oncology Department under construction at Nottingham City Hospital. The order is for Philips SL20 dual mode Linear Accelerator, SL75/5 low emery Accelerator and SLS Treatment Simulator with Philips' unique 14" Image Intensifier.

New from Wardray

Wardray have introduced a number of new items to their range of X-ray protective products. An adjustable protective suspension shield can now be mounted on a ceiling supported trolley complete with track. In addition a swivel bracket can be included to give the option of tilting the protective panel.

A new design for ultraflex aprons is undergoing field trials. An adjustable buckle belt for double sided models distributes the weight between shoulders and waist and avoids the need for a wrap-around design with the consequent increase in material and overall weight.

A new style rigid designer frame for lead spectacles is now offered with 0.75mm Pb protection in the front glass lenses and the side acrylic panels.

For further information contact Wardray Products Ltd. Tel: 081-398 9911.

New MRI Audio System is Music to the Ears

Apprehensive, nervous or claustrophobic patients can be made to feel more comfortable during their MRI scans thanks to a new MRI Audio System. Patients can bring their own musical tapes and listen to their own favourite music.

The MRI Audio System headphones are designed to block out up to 92% of the gradient noise associated with MRI scans and is independent of the existing MRI intercom, enabling communication with the patient.

The system includes a programmable digital AM/FM stereo receiver, power amplifier, set of acoustic suspension speakers, single beam laser compact disc player, auto-reverse cassette deck with Dolby sound and two sets of headphones.

For further information contact Nuclear Associates, 100 Voice Road, Carle Place, NY11514-1593,USA. Tel:516 741 6360.

CT Scanner for West Dorset

The new Philips Tomoscan CX/S Scanner was recently opened at Weymouth Hospital by the city's Mayor and Mayoress. The scanner is linked to the Wessex Neuro Centre at Southampton.

The photograph shows from left to right: Mr D. Burnige, Business Manager, Southern Region, Philips Medical Systems; Mr S. Youngs, Superintendent Radiographer; Major General Keightley, Chairman of West Dorset Health Authority; Dr P. Camm, Head of Radiology; Mrs C. Gill, Southern Region Manager, Philips Medical Systems; Mrs Rendell, Mayoress of Weymouth; Mr P. Rendell, Mayor of Weymouth.

Rita! – a New X-ray Digitizer

The Rita! (Radiographic Imaging Transmission and Archive) workstation enables high resolution medical images to be converted from film to digital form, optically archived, and transmitted to multiple locations within the hospital — or anywhere in the world.

For further information contact Laser Lines Ltd, Beaumont Close, Banbury, Oxon OX16 7TQ. Tel: 0295 267755.

TOSBEE from Toshiba

Toshiba Medical Systems recently launched a new alpha-series ultrasound machine which is especially suitable for Gynaecologists, hospital Radiologists and private practitioners. TOSBEE has a sharp, clear image quality and is very easy to use with operating controls kept to a minimum.

For further information contact Toshiba Medical Systems Europe BV, Schieweg 1, 2627 AN Delft, The Netherlands. Tel: 015 61 01 21.

Leading-Edge Imaging Systems at Image Processing '90

Transtechnology Europe introduced ISG Technologies' CAMRA Sun-based three-dimensional medical imaging system at a recent conference in London. This CAMRA (Computer Assisted Medical Reconstruction and Analysis) system has been very successful in the USA. It offers exceptional image quality and connects easily to a wide range of Magnetic Resonance and CT scanners to provide sophisticated 2-D and 3-D reconstructions and analysis of both soft and bony structures.

The system consists of a Sun workstation operating as a general-purpose host computer combined with ISG's processing hardware and fully-integrated 3-D biomedical volume investigation software.

Transtechnology Europe Ltd is the European subsidiary of Transtechnology Corporation, California. It produces and markets high resolution graphics displays and markets leading-edge computer imaging hardware and software.

For further information call Mark Hope on 0705 863631.

BIR Company Subscriber Scheme

The BIR company subscriber scheme is aimed at all companies with and interest in radiology and addied sciences.

For and annual subscription of £250 p.a. member companies are offered an attractive benefits package.

To find out why your company should join the leading edge companies listed below, please contact Mr Tony Hudson, Administration Manager, British Institute of Radiology, 36 Portland Place, London W1N 4AT. Tel: 071-580 4085.

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27 Great West Road, Brentford, Middlesex TW8 9AX.
Tel. 081-560 2131. Product Areas 1. Contact Mr G. Mountford, Director.

American Medical Ltd
PO Box 971, London SW10.
Tel. 071-352 8051. Fax: 071-376 4508.
Product areas 1, 3, 4, 5, 7, 8.
Contact Betsy Riley, Managing Director.

Amersham International PLC
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Tel. 0296 395222.
Product areas 4, 5, 6.
Contact Mr James McLaughlin, Sales and Marketing Manager.

Bard Ltd
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Tel. 0293 27888, ext. 2204.
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British Nuclear Fuels plc
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Tel. 0925 835022.
Product areas 8, 11. Contact Dr R. J. Berry, Director of Health and Safety and Environmental Protection.

Bruel & Kjaer (UK) Ltd
92 Uxbridge Road, Harrow, Middlesex, HA3 6BZ.
Tel. 081-954 2366.
Product areas 3, 6.
Contatct Mr Dennis Lewis, Sales Manager.

Cardiac Services Ltd
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Product areas 1, 3, 4, 5, 6.
Contact Mr R. J. Brown. Managing Director.

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1st UAE Diagnostic Radiology and Imaging Conference
January 14–17, 1991
Abu Dhabi, United Arab Emirates
Further details: Dr Abdul Rahim Jaafar, Chairman, Organizing Committee, Assistant Under-Secretary, Ministry of Health, Mafraq Hospital, PO Box 2951, Abu Dhabi, UAE. Fax: 21549.

Diagnostic Radiology in Aruba
January 20–26, 1991
Aruba
Further details: Radiology Postgraduate Education Office, Cornell University Medical College, 1300 York Avenue, New York, NY 10021, USA. Tel: (212) 746 2522.

Computed Body Tomography 1991 — The Cutting Edge
February 7–10, 1991
Florida, USA
Further details: Program Coordinator, The Johns Hopkins Medical Institutions, Office of Continuing Education, Turner Building, 720 Rutland Avenue, Baltimore, Maryland 21205.
Tel: (301) 955-2959.

Joint RCOG/RCR Theoretical Course in Obstetric Ultrasound
February 11–15, 1991
London
Further details: The Conference Office, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG.
Tel: 071-636 4432. Fax: 071-323 3100.

Clinical Oncology Symposium: Challenges Brachytherapy
8 March, 1991
London
Further details: The Conference Office, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG.
Tel: 071-636 4432. Fax: 071-323 3100.

Marie Curie Memorial Foundation Second International Cambridge Conference on Breast Cancer Screening
April 15–17, 1991
Cambridge
Further details: International Cambridge Conference on Breast Cancer Screening, Education Department, 11 Lyndhurst Gardens, London NW3 5NS.
Tel: 071-435 4305.

Joint RCR/RCGP Meeting Radiology in Practice
23 April, 1991
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Further details: The Conference Office, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG.
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8th International Workshop on Bone Dosimetry
April 28–May 2, 1991
Bad Reichenhall, Germany
Further details: Dr Deiter Felsenberg, Freie Universität Berlin, Klinikum Steglitz, Hindenburgdamm 30, D-1000 Berlin 45, Germany.

American Radium Society Annual Meeting
May 4–8, 1991
Paris, France
Further details: Office of the Secretariat, American Radium Society, 1101 Market Street, 14th Floor, Philadelphia, PA 19107, USA. Tel: (215) 574 3179.

Advance Oncology: Paediatric Cancer
May 10–11, 1991
London
Further details: The Conference Office, The Royal College of Radiologists, 38 Portland Place, London W1N 3DG.
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EuroPACS 91
July 2–3, 1991
Berlin, Germay
Further details: Professor Heinz U. Lemke, c/o University Klinikum Rudolf Virchow - Wedding, Altes Rontgenhaus-Raum 1005, Augustenburger Platz 1, D-1000 Berlin 65.

CAR '91 (Computer Assisted Radiology)
July 3–6, 1991
Berlin, Germany
Further details: Professor Heinz U. Lemke, c/o University Klinikum Rudolf Virchow - Wedding, Altes Rontgenhaus-Raum 1005, Augustenburger Platz 1, D-1000 Berlin 65.

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Second International Congress on Ultrasound and the Skin
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Modena, Italy
Further details: Stefania Seidenari, Dept. of Dermatology, Policlinico - via del Pozzo, 71 41100 Modena, Italy.

Dublin 91: Annual Scientific Meeting and Exhibition
September 25–28, 1991
Dublin, Ireland
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Practical implications of ICRP 1991
October 1, 1991
London
Further details: Dr D. N. S. Dixon, Programme Committee Secretary, The Society for Radiological Protection, 67 Oatlands Park, Linlithgow, West Lothian EH49 6AS.
Tel: 031-244 2779.

The Tenth Annual Scientific Meeting and Exhibitin of the Society of Magnetic Resonance in Medicine
October 16, 1991
California, USA
Further details: SMRM, 1918 Universi Avenue, Suite 3c, Berkeley, CA 94704, USA. Tel: (415) 841-1899.
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Eighth International Symposium, Radionuclides in Nephrourology
May 6–8, 1992
Chester
Further details: Mr P. H. O'Reilly, Department of Urology, Stepping Hill Hospital, Stockport, Cheshire SK2 7JE.
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OPTIMIZATION OF IMAGE QUALITY AND PATIENT EXPOSURE IN DIAGNOSTIC RADIOLOGY

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(BIR Report 20)

Editors:

B M Moores, *Radiation Protection Service, Liverpool, UK*
B F Wall, *National Radiological Protection Board (NRPB), UK*
H Eriskat, *Commission of the European Communities (CEC), Luxembourg*
H Schibilla, *Commission of the European Communities (CEC), Brussels*

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Tolerances, Limiting Values and Appropriate Measuring Methods

(BIR Report 18)

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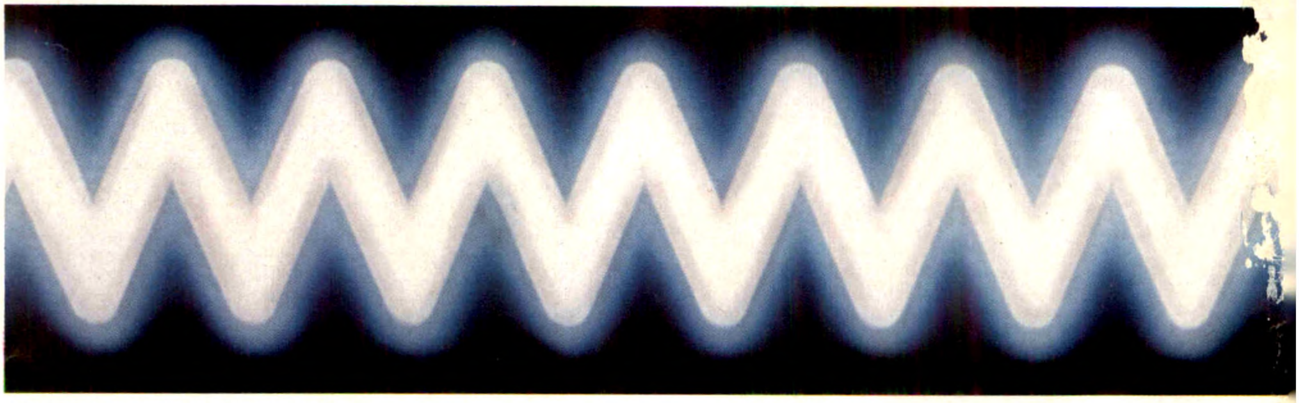

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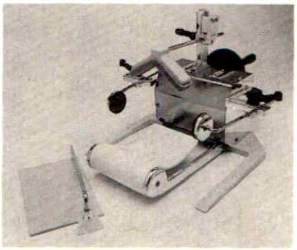

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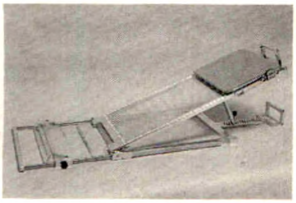

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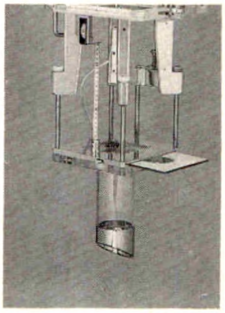

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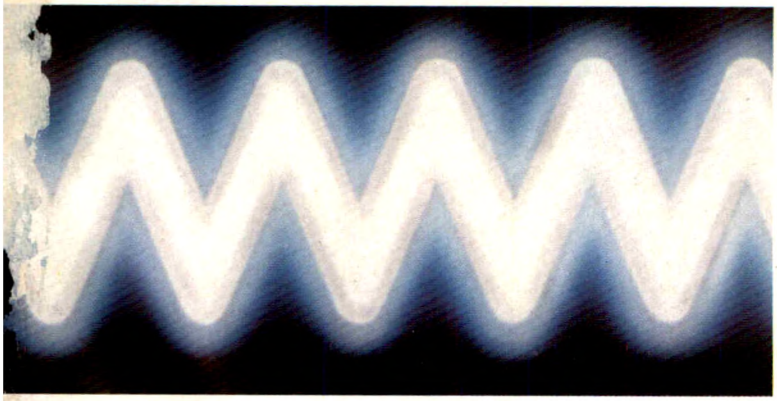

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S C Lillicrap, *Royal United Hospital, Bath, UK*
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BIR Special Report 10 discussed the experiences of the first radiotherapy centres with treatment simulators and drew together a consensus of opinion on the requirements for both technical specification and accommodation as well as drawing up guidelines for future developments. BJR Supplement 16 was a revision of Special Report 10 and reflected the fact that several manufacturers had accepted its recommendations. This latest revision takes account of the developments of the last 7 years and in particular the rapid growth in computer technology, which has meant that the simulator is now at the centre of a network covering the radiation treatment planning computer and the therapy equipment, including recording and verification systems. Linking the treatment planning computer to the CT scanner is discussed and quality assurance is also covered in some detail. This publication will serve as a refresher course for those already using treatment simulators, a comprehensive text for students in radiotherapy, medical physics and radiography, and a useful source of information on technical specifications and practical applications for manufacturers.

Contents: The role of the treatment simulator • Treatment simulator specification • The planning suite • The treatment simulator in practice • Quality assurance • Computers in radiotherapy departments • Other imaging facilities

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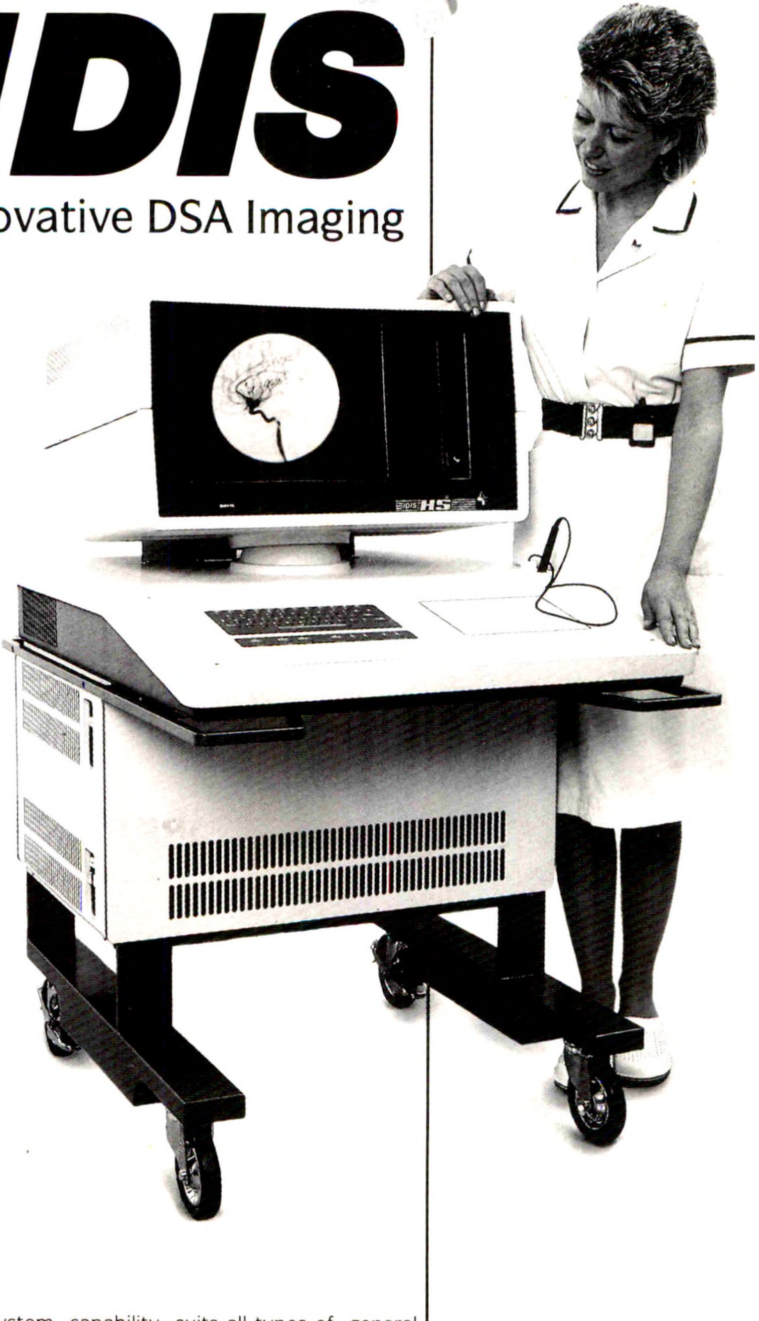

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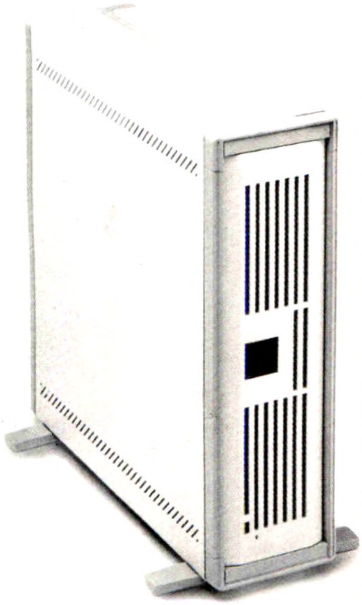

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